Technical Bulletin

0199 - 99 - 3005/7 EN

This Circular supersedes: TR0199-99-3005/6

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Fuels

The 7th replacement was introduced due to more detailed specifications of

- Light heating oils for TIER III and EURO IV engines.
- Introduction of diesel fuel with 7% bio diesel according to DIN 51628
- Release of plant oils for DEUTZ NATURAL FUEL ENGINE®

This Technical Circular applies for all air-cooled and liquid-cooled compact engines made by DEUTZ. This TC applies accordingly for engines which are no longer built.

General

The following fuels are permitted for the compact engines made by DEUTZ:

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

For general fuel data, see subsection:

- Biological contamination in fuels
- Fuel additives

Distillate fuels with residue oil percentages or mixed fuels may not be used in DEUTZ compact engines.

The DEUTZ vehicle engines are designed for diesel fuels in accordance with EN 590 and DIN 51268 with a cetane number of at least 51. DEUTZ engines for mobile machinery are designed for a cetane number of at least 45. When using fuels of a low cetane number, troublesome white smoke and ignition misfires are to be expected under some circumstances.

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.

A cetane number of at least 40 is permissible for the US market, therefore special engine models have been developed to avoid starting difficulties, extreme white smoke or increased hydrocarbon emissions (EPA specification – US EPA REGULATIONS FOR LARGE NONROAD COMPRESSION-IGNITION ENGINES).

If the white smoke behaviour is unacceptable when using a very low cetane number, the use of ignition improvers is to be recommended as a later remedial measure. If the use of fuels with a very low cetane number can be anticipated, we recommend ordering engines in the EPA version.

The certification measurements for compliance with the legal emission limits are carried out with the test fuels prescribed by law. These correspond to the diesel fuels in accordance with EN 590, DIN 51628 and ASTM D 975 described in subsection 1. No emission values are guaranteed with the other fuels described in this bulletin. It is the obligation of the owner to check permissibility for the use of fuels in accordance with regional regulations.

Engines which are fitted with an exhaust aftertreatment via a particle filter, oxidation catalyst or SCR system (**S**elective **C**atalytic **R**eduction), may only be operated with diesel fuel according to EN 590 or DIN 51628. Otherwise, compliance with emissions requirements and durability are not guaranteed.

Diesel fuels

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

Fuel	Specifications
EN 590 (max. 5% bio-diesel)	Appendix 2
DIN 51628 (max. 7% bio-diesel)	Appendix 3
ASTM Designation: D 975 Grade-No 1-D and Grade Low Sulphur No. 1-D	Appendix 4
ASTM Designation: D 975 Grade-No 2-D and Grade Low Sulphur No. 2-D	Appendix 4
JIS K 2204 Grade 1 Fuel and Grade 2 Fuel	Appendix 5
NATO F-54, corresponds to diesel fuel in accordance with EN 590	Appendix 2

The European standard EN 590 has the status of a national standard with national appendix in most European countries, e.g. EN 590.

For DEUTZ engines for Tier III and EURO III/IV with electronic injection, US diesel fuels according to ASTM D 975 Grade-No 1-D and 2-D are approved. Japanese diesel fuels in accordance with JIS K 2204 Grade 1 Fuel and Grade 2 Fuel are only approved if the lubricating properties comply with the diesel fuel EN 590 (HFRR max. 460 micrometer according to EN ISO 12156).

Lubricity in low sulphur and sulphur-free fuels

Insufficient lubricity can lead to serious wear problems, above all in common rail injection systems. A lubricity which is too low is a particular problem in fuels with a low sulphur content (and in this regard, sulphur contents of <500mg/kg may be considered low). In low sulphur (<50mg/kg) and sulphur-free (< 10mg/kg or <15mg/kg) diesel fuels, in accordance with EN 590, DIN 51628 and ASTM D 975, sufficient lubricity is guaranteed by appropriate additives. The lubricity of low sulfur diesel fuels which do not comply with these standards must be guaranteed by additives. The parameter for adequate lubricity is a maximum wear spot of 460 micrometers in the HFRR test (ISO 12156-1).

High sulphur content in the fuel

Fuels with sulphur content > 0.5 weight % require a shorter lubricating oil change interval (see Technical Circular 0199--99-3002). Fuels with a sulphur content >1.0 weight % are not permissible due to high corrosion and considerable shortening of the engine life.

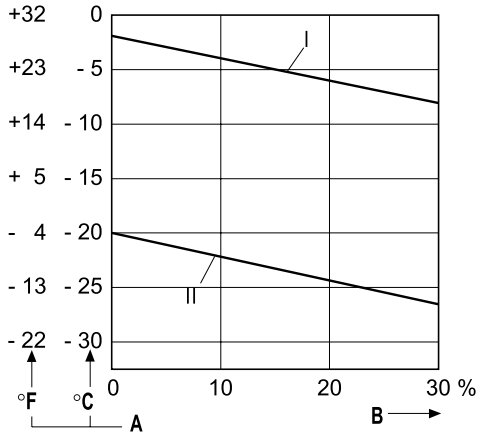
Low-ash engine oils (low SAPS oils, sulphated ash <1.0 weight%) may not be used with fuels with sulphur content > 500 mg/kg.

Winter operation with diesel fuel

Special demands are made on the behaviour in cold (temperature limit of filterability) for Winter operation. Suitable fuels are available at fuel stations at the specified times.

If only summer diesel fuel is available, up to 30% petroleum can be mixed with the diesel according to the diagram below at low temperatures to ensure the flow properties.

Mixing with petroleum is not allowed for TCD 2013 4V engines and fuels in accordance with ASTM D 975 1-D/2-D.



A 1 Mixing petroleum with the summer diesel fuel

Mixing should take place in the engine tank: First fill with the necessary amount of petroleum and then top up with diesel.

Mixing of regular gasoline 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. Mixing flow improvers with the diesel fuel is possible. The choice of a suitable additive and the necessary dosing and mixing procedure should be made in agreement with the fuel supplier.

Marine distillate fuels

These are distillate fuels which are principally used in ships. Only marine distillate fuels which contain no residual oils (residues from the distillation process) may be used.

The following marine distillate fuels may be used for DEUTZ marine engines:

Fuel	Specifications
ISO 8217 DMX	Appendix 6
ISO 8217 DMA (restriction: sulphur content max 1.0 weight%)	Appendix 6
NATO F-75	Appendix 7
NATO F-76	Appendix 8

- Marine distillate fuels are not approved for engine series 2008, 2009, 2015 and engines for Tier III and EURO IV with electronic injection.
- The cetane number must be at least 40, otherwise starting difficulties, extreme white smoke or increased hydrocarbon emission may occur.
- The higher density requires a return blocking in the injection pump (may only be carried out by authorised DEUTZ personnel).
- The possible high sulphur content ≥ 0.5 weight% requires a shorter lubricating oil change interval. Fuels with a sulphur content >1.0 weight % are not permissible due to high corrosion and considerable shortening of the engine life. Please bear in mind, therefore, that fuels in accordance with ISO 8217 DMA are only permissible, when the sulphur content is a maximum of 1.0 weight%.
- Due to the possible severe soiling, the fuel purification is particularly important, and if necessary an additional fuel filter with water separator may be installed.

Non-road fuels and light heating oils

In some European countries, non-road fuels are defined with the same properties as heating oil, but they are treated differently from heating oil for tax purposes. In Germany, systems which benefit from permission to use heating oils are described in the Energy Taxation Law (Section 3). Heating oils are usually not allowed in diesel engines. The user must always keep to the relevant tax regulations. These are not the subject of this bulletin. Regarding their application in engines (warranty claims), there is no difference between the corresponding non-road fuels and light heating oils.

The following non-road fuels and light heating oils can be used:

Fuel	Specifications
DIN 51603	Appendix 9
ASTM D 396 Grade-No 1	Appendix 10
ASTM D 396 Grade-No 2	Appendix 10
BS 2869 Class A2	Appendix 11
CSR 441	Appendix 12

- 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).
- For engines for Tier III and EURO IV with electronic injection, light heating oils may only be used if they comply with all limit values of EN 590 except the fuel density, the cetane number and the sulphur content. For these parameters, the following limit values apply:

Fuel parameter	Unit	Limit value	Test method
Cetane number		min. 49	EN ISO 5165
Fuel density at 15°C	kg/m^3	820 - 860	EN ISO 3675 or EN ISO 12185
Sulphur content	mg/kg	max. 1000	EN ISO 14596

Jet fuels

The following jet fuels can be used:

Fuel	Specifications
F 34/F 35 (kerosene, NATO designation)	Appendix 13
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)	Specifications available on request
JP-8 (kerosene, US military designation)	
JP-5 (kerosene, US military designation)	
Jet A (kerosene for civil aviation)	
Jet A1 (kerosene for civil aviation)	

- Jet fuels F 34 and F 35 are equivalent for use in diesel engines.
- The 1011/2011/912/913/914/2012/2013/2015 engine series are released up to Tier II and Euro III. These series are also released for Tier III in the case of engines with mechanical injection. Tier III and EURO IV engines with electronic injection are not approved for jet fuels
- Jet fuels may not be used for the 226/327/302/916/2008/2009/2010 engine series.
- The cetane number must be at least 40, otherwise starting difficulties, extreme white smoke or increased hydrocarbon emission may occur.
- A power loss of up to 10% is possible due to the lower density and the greater leak fuel rate due to lower viscosity, depending on engine speed and torque. **Blocking of the fuel injector is not allowed.**

- Since the jet fuels F 34/F 35 and F 44 are kerosene, there are some problematical fuel properties (viscosity, lubricity and low boiling point). A slight increase in wear on the injection system is to be expected, which may be reflected in a statistically shorter life of these components. The engine guarantee is retained when these fuels are used.
- Jet fuels can be mixed with each other. Mixing of kerosene with diesel fuel in accordance with EN 590 in order to improve the flow properties in winter operation is permitted.

Bio fuels

We understand bio fuels to mean bio-diesel and pure plant oils (rape seed oil).

Bio-diesel

At first only rape seed oil methylester (RME) was sold as bio-diesel in Europe, but fatty acid methylesters (FAME) based on other oils have come onto the market increasingly in recent years. However, with the latter there is a risk that the limit values of EN 14214 are not kept in the field. Since the quality of bio-diesel available in the market does not always meet requirements, DEUTZ customers in Germany are recommended to ensure quality by buying bio-diesel with an AGQM certificate (Arbeitsgemeinschaft Qualitäts-Management Biodiesel e. V.). Customers should also ensure that suppliers can confirm their compliance with quality requirements by showing a current certificate of analysis from a certified laboratory.

The use of US bio-diesel based on soy oil methylester is only permissible in mixtures with diesel fuel with a bio-diesel part of a max. 20 weight%. The US bio-diesel used for the mixture must comply with the ASTM D6751-07a (B100) standard. The use of bio-diesel whose quality has been assured in accordance with BQ 9000 is recommended.

Fuel	Specifications
Bio-diesel in accordance with EN 14214	Appendix 14
US bio-diesel in accordance with ASTM D6751 - 07a (B100) (only permissible for mixtures with diesel fuel of 20 weight%)	Appendix 15

Released engines

- The 912, 913, 914, 1011, 2011, 1012, 2012, 1013, 2013, 413 and 513 series are released for bio-diesel from year of manufacture 1993 under compliance with the basic conditions specified below.
- The TCD 2012 2V/4V and TCD 2013 2V/4V series for mobile machinery are released for bio-diesel in accordance with EN 14214 as well as a mixture of up to 20% US bio-diesel in accordance with ASTM D6751-07a (B100). The TCD 2013 4V series for commercial vehicles (EURO III/EURO IV) are not released for bio-diesel fuels.
- The 909, 910, 1015, 2008, 2009, 2015 series are not released for bio-diesel as a series standard. Further information is available from head office.
- Turbocharged engines are excepted from release for applications which are usually operated with a high load above 80% of rated output power.
  - Engines in district heating power stations
  - Engines in electricity generators with mains/parallel operation
  - Engines in harvesting machinery

Basic conditions to be observed

- A power loss of 5-9% and increased fuel consumption of 7-8% in relation to diesel fuel in accordance with EN 590 is possible due to the lower heating value. Blocking of the fuel injector is not allowed.
- The lubricating oil quality must correspond to TR 0199-99-3002. The lubricating oil change interval must be halved in relation to operation with diesel fuel in accordance with EN 590.
- Shutdown periods of longer than 4 to 6 weeks must be avoided with bio-diesel. Otherwise the engine must be started and stopped 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 hoses, the manual fuel supply pumps and the LDA diaphragms (series 1012, 1013, 2012, 2013, TCD 2012 2V mechanical and TCD 2013 2V mechanical) are not resistant to bio-diesel and must be changed once a year. Since the fuel hoses may disintegrate earlier with increasing fuel temperature and long running times, they may have to be replaced before the year is out. The fuel hoses must be checked for damage (swelling) in the course of daily maintenance E 20. The use of bio-diesel-resistant fuel hoses (Viton) is recommended, in which case there is no need to change them every 12 months.
- Bio-diesels can be mixed with normal diesel fuel, but the basic conditions described in this subsection apply for mixtures. Mixtures with a percentage of 5% or 7% (V/V) bio-diesel (B5 or B7), as permissible in EU countries according to national legislation, are excluded. In any case, however, bio-diesel mixtures must comply with EN 14214.
- 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.
- The fuel pre-filter must be suitable for operation with bio-diesel.

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 engines based on the TCD 2012 2V/4V and TCD 2013 2V/4V series with the DEUTZ Common Rail System ® (DCR) for use with rape seed oil.

These engines are released for use with 100% rape seed oil (raffinate or cold-pressed) in accordance with DIN V 51605 (appendix 16) and bio-diesel in accordance with EN 14214 (appendix 14).

Basic conditions to be observed

- A power loss of 5-10% and increased fuel consumption of 4-5% in relation to diesel fuel in accordance with EN 590 is possible due to the low heating value. Blocking of the fuel injector is not allowed.
- This motor has a 2 tank system with the possibility of using diesel fuel/rape seed oil. Alternatively, bio-diesel can also be used in place of rape seed oil and/or diesel fuel.
- Rape seed oil must be replaced by diesel fuel or bio-diesel at temperatures of under 5°C.
- 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 quality must correspond to TR 0199-99-3002. The lubricating oil change interval must be halved in relation to operation with diesel fuel in accordance with EN 590.
- Important fuel properties, such as for example water content; oxidation stability; calcium, magnesium and phosphorous content; and the total contamination, are particularly influenced by the harvest time, the pressing process in the oil mill, the storage of the rape seed oil and the continuing logistics chain. Therefore, due to continual infringements of limit values by decentralised oil mills, customers are recommended to confirm the quality of the supply of rape seed oil fuel with a certificate of analysis. In case of doubt, the quality can be proven with an analysis by a laboratory accredited according to ISO 17025 (e.g. ASG Analytik GmbH, D-86356 Neusäß, Tel. ++49 (0)821-450-423-0).
- Mixing with other plant oils, such as sunflower oil, soy oil or palm oil, is not permitted.

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

- Store in the dark and at consistent low temperatures (maximum 20°C, ideally in underground tanks at 5-10°C). Storage temperatures of lower than freezing should be avoided, for this reason also underground tanks are ideal. Tanks must not be translucent (no polyethylene tanks).
- The storage of rape seed oil at storage temperatures of up to 20°C is limited to a maximum of 6 months, in underground 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 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 rape seed oil fuel according to the DIN pre-standard DIN V 51605, see appendix 15.

Biological contamination in fuels

Symptoms

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

- Internal tank corrosion,

- Filter blockage and the associated loss of power due to gel-like deposits on the fuel filter (especially after long downtimes)

Cause

Micro-organisms (bacteria, yeasts, funguses) can form bio-sludge under favourable conditions (favoured particularly by heat and water).

Penetration by water is usually caused by condensation of the water in the air. Water does not dissolve in fuel so that the penetrating water collects at the bottom of the tank. The bacteria and funguses grow in the watery phase, at the phase boundary to the fuel phase, from which they draw their nutrition. There is an increased risk of this especially with bio-diesel (FAME).

In suspicious cases, biological contamination can be analysed according to DIN 51441 (determination of the number of colonies in mineral oil products in the boiling range below 400 °C) by laboratories certified according to ISO 17025 (e.g. PetroLab GmbH, D-67346 Speyer, Tel.: ++49 (0) 6232-33011).

Remedial measures

- Keep the storage tank clean, regular cleaning of the tank 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 from

  Fa. Schülke & Mayr GmbH,
  D-22840 Norderstedt,
  Tel.: +49 (0)4052 100-0,
  E-mail: sai@schuelke-mayr.com

  if the fuel system and storage tank have already been attacked by micro-organisms. The biocide must be dosed according to the manufacturer's specifications.

- Avoid direct exposure of the storage tank to sunlight- Use smaller storage tanks with corresponding low holding times of the stored fuel

Fuel additives

The use of fuel additives is not permitted. The flow improvers mentioned above are an exception. Use of unsuitable additives will result in loss of warranty.

Service Information

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Appendix 1:
Explanation of basic fuel properties

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. At the same control linkage setting, the engine output increases with higher density.

Boiling curve

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

Viscosity

The kinematic viscosity is specified in mm^2/s at a certain temperature (1 mm^2 s^{-1} = 1 cSt [Centistoke]). The viscosity must be within certain limits for engine operation. Too high a viscosity requires pre-heating.

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).

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.

Coke residue

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

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.

Ash

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

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.

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.

Centane number/centane index

The centane number indicates the fuel's willingness to ignite. Too low a centane number may lead to starting difficulties, formation of white smoke, increased carbon emission and thermal and mechanical overloading of the engine. The centane number is determined on a test engine. The centane index can be used alternatively as a calculated value of density and boiling behaviour and usually correlates well with the centane number.

Heating value

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

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.

Copper corrosion

Diesel fuel can have a corrosive effect especially during long storage with temperature changes and formation of condensation on the tank walls. To check the limit value defined in DIN EN 590 and DIN 51628, a polished copper strip is immersed in diesel fuel at 50°C for 3 hours. The appropriate additives also serve to protect the metals which come into contact with the fuel under difficult conditions.

Oxidation resistance

Fuels may oxidise and polymerise partly during long storage. This can lead to the formation of insoluble (varnish like) ingredients and the associated filter blockage.

Lubricity

The lubricity diminishes with the degree of desulfurization and can drop so far that there is considerable wear in the distributor fuel injectors and CR systems. Extremely desulfurized fuels contain special lubricity additives. The HFRR test (High Frequency Reciprocating Wear Rig) has been developed for evaluation of the fuels. This test simulates the sliding wear in the fuel injector by rubbing a ball onto a polished steel plate with a constant pressing force. The flattening of the ball which has resulted after 75 minutes is measured as the average wear diameter (limit value 460 µm).

Appendix 2:
Fuel specification (requirements and test methods):
Diesel fuel according to EN 590 **

Properties	Units	Limit values EN 590	Test method
Cetane number		min. 51	EN ISO 5165
Cetane index		min. 46	EN ISO 4264
Density at 15 °C	kg/m^3	820 - 845	EN ISO 3675/EN ISO 12185
Polycyclic aromatic hydrocarbons	Weight%	max. 11	EN 12916
Sulphur content	mg/kg	50,00 ***	EN ISO 20846/EN ISO 20847
		10,00	EN ISO 20884
Flashpoint	°C	min. 55	EN ISO 2719
Coke residue (from 10% distillation residue)	Weight%	max. 0.30	EN ISO 10370
Ash content	Weight%	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
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. % collected at	°C	360	
fatty acid methylester content (FAME)	%(V/V)	5	EN 14078
Limit of filtrability *			EN 116
- 15.04. to 30.09.	°C	max. 0	
- 01.10. to 15.11.	°C	max. - 10	
- 16.11. to 28.02.	°C	max. - 20	
- 01.03. to 14.04.	°C	max. - 10	

* specifications apply for Germany. National regulations may deviate.

** Specification also applies for NATO fuel F-54

*** permitted until 31.12.2008

Appendix 3:
Fuel specification (requirements and test methods):
Diesel fuel according to DIN 51628

Properties	Units	Limit values DIN 51628	Test method
Appearance	Clear and non-cloudy at temperatures above the cloud point		Visual assessment
Cetane number		min. 51	EN ISO 5165
Cetane index		min. 46	EN ISO 4264
Density at 15 °C	kg/m^3	820 - 845	EN ISO 3675 EN ISO 12185/C1
Polycyclic aromatic hydrocarbons	Weight%	max. 8	EN 12916
Sulphur content	mg/kg	50,00 ***	EN ISO 20884
		10,00	EN ISO 20846/EN ISO 20884
Flashpoint	°C	min. 55	EN ISO 2719
Coke residue (from 10% distillation residue)	Weight%	max. 0.30	EN ISO 10370
Ash content	Weight%	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. 20.0	DIN 51627-2
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. % collected at	°C	360	
fatty acid methylester content (FAME)	%(V/V)	7	DIN 51627-1
Limit of filtrability *			EN 116
- 15.04. to 30.09.	°C	max. 0	
- 01.10. to 15.11.	°C	max. - 10	
- 16.11. to 28.02.	°C	max. - 20	
- 01.03. to 14.04.	°C	max. - 10	

* specifications apply for Germany.

*** permitted until 31.12.2008

Appendix 4:
Fuel specification (minimum requirement)
Diesel fuel according to ASTM Designation D 975-02

Properties	Units	Limit values		Test method
		Grade No. 1-D Grade Low Sulphur No. 1-D	Grade No. 2-D Grade Low Sulphur No. 2-D	
Density at 15 °C	kg/m^3	max. 860 *	max. 860 *	ASTM D 1298
Flashpoint	°C	min. 38	min. 52	ASTM D 93
Water and sediments	Vol.%	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	1,9 - 4,1	ASTM D 44
Ash content	Weight%	max. 0.01	max. 0.01	ASTM D 482
Sulphur content - Grade No. 1/2-D - Grade Low Sulphur No. 1/2-D	 Weight% Weight%	 max. 0.50 max. 0.05	 max. 0.50 max. 0.05	 ASTM D 129 ASTM D 2622
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	Weight%	0,15	0,35	ASTM D 524
Limit of filtrability	°C	**	**	

* minimum requirement DEUTZ

** depending on season and region

Appendix 5:
Fuel specification (minimum requirements)
Diesel fuel in accordance with JIS K 2204

Properties	Units	Limit values		Test method
		Grade 1 Fuel	Grade 2 Fuel	
Flashpoint	°C	min. 50	min. 50	ISO 3405 ISO 3924
Boiling curve at 90 vol. %	°C	max. 360	max. 350	ISO 3405 ISO 3924
Pour point	°C	max. -2.5	max. -7.5	ISO 3015 ISO 3016
Limit of filtrability	°C	max. -1	max. -5	ICS 75.160.20
Coke residue (from 10% distillation residue)	mg	max. 0.1	max. 0.1	ISO 4260 ISO 4260
Cetane index		min. 50	min. 45	ISO 5163 ISO 5164 ISO 5165 ISO 4264
Kinematic viscosity at 30°C	Vol.%	min. 2.7	min. 2.5	ISO 2909 ISO 3104
Sulphur content	Weight%	max. 0.05 *	max. 0.05 *	ISO 4260 ISO 8754

* from 2005 max. 0.005 weight %

Appendix 6:
Fuel specification (minimum requirement)
Distillate fuel in accordance with ISO 8217

Properties	Units	Limit values Category ISO-F		Test method
		DMX	DMA	
Density at 15 °C	kg/m^3	max. 890	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	°C	–	max. -6	ISO 3016
- Summer	°C	–	max. 0	ISO 3106
Cloud point	°C	max. - 16 **	–	ISO 3015
Sulphur content	Weight%	max. 1.0 ***	max. 1.0 * ***	ISO 8754
Cetane number		min. 45	min. 40	ISO 5165
Coke residue (from 10% distillation residue)	Weight%	max. 0.30	max. 0.30	ISO 10370
Ash content	Weight%	max. 0.01	max. 0.01	ISO 6245

* minimum requirement DEUTZ

** This fuel can be used up to - 15 °C without pre-heating.

*** Observe shorter lubricating oil maintenance interval

Appendix 7:
Fuel specification (minimum requirement)
Diesel fuel according to NATO specification

Properties	Units	Limit values F-75 *	Test method
Density at 15 °C	kg/m^3	815 - 860	DIN 51757
Kinematic viscosity at 40 °C	mm^2/s	1,8 - 4,3	DIN 51562 part 1
Flashpoint	°C	min. 61	DIN EN 22719
Cloud point	°C	max. -13	DIN EN 23015
Pour point	°C	max. -18	DIN ISO 3016
Ash content	Weight%	max. 0.01	DIN EN ISO 6245
Neutralisation number (acid)	mg KOH/g	max. 0.5	DIN 51558 part 1
Neutralisation number (water soluble acids)	mg KOH/g	0,0	DIN 51558 part 1
Sulphur content	Weight%	max. 0.05	DIN 51400 part 1 and 6
Corrosion effect on copper (3 h at 100 °C)	Degree of corro-sion	max. 1	DIN EN ISO 2160
Coking tendency	Weight%	max. 0.16	DIN 51551 part 1
Boiling curve at 90 vol. % Boiling curve at 90 vol. %	°C °C	max. 357 max. 385	DIN 51751
Cetane number		min. 45	DIN 51773
Water content	mg/kg	max. 200	DIN 51777 part 1
Sediments	mg/l	max. 10	ASTM D 2276 App. A 2
Demulgation capacity	minutes	max. 10	ISO 6614

* National specifications
DE = TL 9140-0003
FR = STM 7120 B
IT = MM C 1002/E

Appendix 8:
Fuel specification (minimum requirement)
Diesel fuel according to NATO specification

Properties	Units	Limit values F-76 *	Test method
Density at 15 °C	kg/m^3	820 - 880	IP 160
Distillation - collected at 350 °C	Vol.%	min. 85	IP 123
Kinematic viscosity at 40 °C	mm^2/s	1,7 - 4,3	IP 71
Flashpoint	°C	min. 61	IP 34
Cloud point	°C	max. -1	IP 219
Pour point	°C	max. -6	IP 15
Ash content	Weight%	max. 0.01	IP 4
Neutralisation number	mg KOH/g	max. 0.3	IP 139
Neutralisation number (water soluble acids)	mg KOH/g	0,0	IP 182
Sulphur content	Weight%	max. 1.0 **	IP 336
Corrosion effect on copper (3 h at 100 °C)	Degree of corro-sion	max. 1	IP 154
Coke residue (from 10% distillation residue)	Weight%	max. 0.2	IP 14
Cetane number		min. 45	ASTM D 613
Sediments	mg/l	max. 10	

* National specifications
EN = DEF. STAN 91-4
US = MIL-F-16884 J
FR = STM 7120 B
NL = KN 10323

** Observe national requirements, max. 1.0 weight %

Appendix 9:
Fuel specification (minimum requirement)
Light heating oil in accordance with DIN 51603-1

Properties	Units	Limit values DIN 51603-EL-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	above 55	EN 22719
Kinematic viscosity at 20 °C	mm^2/s	max. 6.0	DIN 51562-1
Distillation curve total evaporated volume parts			EN ISO 3405 or ASTM D 86
- up to 250 °C	%	max. 65	
- up to 350 °C	%	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	%	max. -12	
- at cloud point = 2 °C	%	max. -11	
- at cloud point < 1 °C	%	max. -10	
Coke residue (from 10% distillation residue) according to Conradson	Weight%	max. 0.3	EN ISO 10370 or DIN 51551-1
Sulphur content	mg/kg	min. above 50	EN 24260 orEN ISO 8754 or EN ISO 14596
- for heating oil EL-1 standard	%	max. 0.1	
Sulphur content	mg/kg	max. 50	EN ISO 20884 or EN ISO 20846
- for heating oil EL-1 low sulphur	%	max. 0.0050	
Water content	mg/kg	max. 200	DIN 51777-1 or EN ISO 12937
Total contamination	mg/kg	max. 24	EN 12662
Ash content	Weight%	max. 0.01	EN ISO 6245
Thermal stability (sediment)	mg/kg	to be specified	E DIN 51371
Storage and thermal stability	It is not possible to specify a limit value until a suitable method has been developed.		

Appendix 10:
Fuel specification (minimum requirement)
Light heating oil according to ASTM Designation D 396-96

Properties	Units	Limit values ASTM D 396-96		Test method
		No. 1	No. 2	
Density at 15 °C	kg/m^3	max. 850	max. 876	ASTM D 1298
Flashpoint	°C	min. 38	min. 38	ASTM D 93
Water and sediments	Vol.%	max. 0.05	max. 0.05	ASTM 2709
Boiling curve - 10 Vol. % at - 90 Vol. % at	 °C °C °C	 max. 215 – max. 288	 – min. 282 max. 338	ASTM D 86
Kinematic viscosity at 40 °C	mm^2/s	1,3 - 2,1	1,9 - 3,4	ASTM D 445
Sulphur content	Weight%	max. 0.5	max. 0.5	ASTM D 129
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 *	
Coke residue (from 10% distillation residue) according to Ramsbottom	Weight%	max. 0.15	max. 0.35	ASTM D 524
Pour point	°C	max. - 18	max. -6	ASTM D 97

* minimum requirement DEUTZ

Appendix 11:
Fuel specification (minimum requirement)
Light heating oil in accordance with BS 2869

Properties	Units	Limit values BS 2869 Class A2	Test method
Kinematic viscosity at 40 °C			
- Summer (16.3.-30.9.)	mm^2/s	2,0 - 5,5	EN ISO 3104
- Winter (1.10.-15.3.)	mm^2/s	1,5 - 5,5	EN ISO 3104
Density at 15 °C	kg/m^3	min. 820	EN ISO 3675 or EN ISO 12185
Cetane number		min. 45	BS 5580
Coke residue (from 10% distillation residue)	Weight%	max. 0.30	EN ISO 10370
Distillation			
- collected at 250 °C	Vol.%	max. 65	BS 7392
- collected at 350 °C	Vol.%	min. 85	BS 7392
Flashpoint in closed pot according to Pensky-Martens	°C	min. 56	EN 22719
Water content	mg/kg	max. 200	ASTMD 1744
Sediments	Weight%	max. 0.01	EN ISO 3735
Ash content	Weight%	0,01	EN ISO 6245
Sulphur content	Weight%	0,20	EN ISO 8754
Corrosion effect on copper (3 h at 100 °C)	Degree of corrosion	1	EN ISO 2160
Limit of filtrability			
- Summer (16.3.-30.9.)	°C	max. -4	EN 116
- Winter (1.10.-15.3.)	°C	max. -12	EN 116

Appendix 12:
Fuel specification (minimum requirement)
Light heating oil in accordance with CSR 441

Properties	Units	Limit values CSR 441	Test method
Density at 15 °C	kg/m^3 kg/m^3	min. 830 max. 880	EN ISO 3675 EN ISO 12185
Kinematic viscosity at 20 °C	mm^2/s	max. 9.5	EN ISO 3104
Sulphur content	Weight%	max. 0.20	EN 24260 EN ISO 14596
Distillation - collected at 250 °C - collected at 350 °C	 Vol.% Vol.%	 max. 65 min. 85	 EN ISO 3405 EN ISO 3405
Flashpoint	°C	min. 55	NF T 60-103
Water content	mg/kg	max. 200	ISO 6296 EN ISO 12937
Water and sediments	Weight%	max. 0.10	NF M 07-020
Oxidation stability	g/m^3	max. 25	EN ISO 12205
Pour point	°C	max. -9	NF T 60-105
Limit of filtrability	°C	max. -4	EN 116
Coke residue (from 10% distillation residue)	Weight%	max. 0.35	ISO 6615 EN ISO 10370
Cetane number		min. 40	EN ISO 5165

Appendix 13:
Fuel specification (minimum requirement)
Jet fuels

NATO code F-34/F-35

Properties	Units	Limit values NATO Code F-34/F-35 *	Test method **
Density at 15 °C	kg/m^3	775-840	DIN 51757
Boiling curve			
- at 10 Vol.% distillate amount	°C	max. 205	DIN 51751
- Boiling end point	°C	max. 300	
- Distillation residue	Vol.%	max. 1.5	
- Distillation loss	Vol.%	max. 1.5	
Kinematic viscosity	mm^2/s	max. 8.0 at -20 °C	DIN 51562-1
Flashpoint	°C	min. 38	EN ISO 2719/IP 170
Sulphur content	Weight%	max. 0.20	DIN 51400-1and 6
Ash content	Vol.%	–	EN ISO 6245
Water content	mg/kg	–	DIN 51777-1
Sediments	mg/dm^3	–	ASTM D 2276 App. A2
Heating value H_u	MJ/kg	min. 42.8	DIN 51900-1 and -2
Cloud point	°C	–	EN 23015
Pour point	°C	–	DIN ISO 3016
Cetane number		min. 40 ***	DIN 51773
Corrosion effect on copper (2h at 100 °C)	Degree of corrosion	1	EN ISO 2160

* National specifications
D = TL 9130-0012, D. STAN 91-91
USA = MIL-DTL-83133 E
F = DCSEA 134/A
GB = D. STAN 91-87/91
NL = D.STAN 91-87/91

** applies for Germany

*** minimum requirement DEUTZ

NATO code F-44/F-63

Properties	Units	Limit values NATO Code		Test method
		F-44 *	F-63 **	
Density at 15 °C	kg/m^3	788-845	797	ASTM-D 1298
Boiling curve				
- at 10 Vol.% distillate amount	°C	max. 205	max. 205	ASTM-D 86
- Boiling end point	°C	max. 290	max. 300	
- Distillation residue	Vol.%	max. 1.5	max. 1.5	
- Distillation loss	Vol.%	max. 1.5	max. 1.5	
Kinematic viscosity	mm^2/s	max. 8.5 at -20 °C	max. 8.0 at -20 °C	ASTM-D 445
Flashpoint	°C	min. 61	min. 38	ASTM-D 93
Sulphur content	Weight%	max. 0.30	max. 0.20	ASTM-D 1266/ 2622
Ash content	Vol.%	–	–	
Water content	mg/kg	–	–	
Sediments	mg/dm^3	–	–	
Heating value H_u	MJ/kg	min. 42.6	min. 42.8	ASTM-D 240/ 2382
Cloud point	°C	–	–	
Pour point	°C	–	–	
Cetane number		min. 40 ***	min. 48	
Corrosion effect on copper (3 h at 100 °C)	Degree of corrosion	1	1	ASTM-D 130

* National specifications
DE = D. STAN 91-86
USA = MIL-DTL-5624 T degrees JP-5
F = DCSEA 144/A
GB = D. STAN 91-86

** National specifications
F = DCSEA 108/A

*** minimum requirement DEUTZ

Appendix 14:
Fuel specification (minimum requirement)
Fatty acid methylester (FAME) for diesel engines (bio-diesel)

Properties	Units	Limit values EN 14214	Test method
fatty acid methylester content (FAME)	Weight%	min. 96.5	EN 14103
Density at 15 °C	kg/m^3	860 - 900	EN ISO 3675 EN ISO 12185/C1
Viscosity at 40 °C	mm^2/s	3,5 - 5,0	EN ISO 3104/C2
Flashpoint	°C	min. 101	EN ISO 2719/EN ISO 3679
Sulphur content	mg/kg	max. 10.0	EN ISO 20846/EN ISO 20884
Coke residue (from 10% distillation residue)	Weight%	max. 0.30	EN ISO 10370
Cetane number		min. 51	EN ISO 5165
Ash content (Sulphate ash)	Weight%	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	prEN 15751/EN 14112
Acid number	mg KOH/g	max. 0.5	EN 14104
Iodine number	gr lod/100gr	max. 120	EN 14111
content of linolenic acid methylester	Weight%	max. 12.0	EN 14103
Content of polyunsaturated fatty acid methylesters with ≥ 4 double bonds	Weight%	max. 1	
methanol content	Weight%	max. 0.20	EN 14110
monoglyceride content	Weight%	max. 0.80	EN 14105
diglyceride content	Weight%	max. 0.20	EN 14105
triglyceride content	Weight%	max. 0.20	EN 14105
content of free glycerine	Weight%	max. 0.020	EN 14105 EN 14106
content of total glycerine	Weight%	max. 0.25	EN 14105
content of alkaline-metals (Na + K)	mg/kg	max. 5.0	EN 14108 EN 14109 EN 14538

Properties	Units	Limit values EN 14214	Test method
content of earth alkaline-metals (Ca + Mg)	mg/kg	max. 5.0	EN 14538
phosphor content	mg/kg	max. 4.0	EN 14107
Limit of filtrability			EN 116
- 15.04. to 30.09.	°C	max. 0	
- 01.10. to 15.11.	°C	max. - 10	
- 16.11. to 28.02.	°C	max. - 20	
- 01.03. to 14.04.	°C	max. - 10	

* specifications apply for Germany. National regulations may deviate.

Appendix 15:
Fuel specification (minimum requirement)
US-bio-diesel in accordance with ASTM D 6751-07a (B100)

Properties	Units	Limit values ASTM D 6751-07a	Test method
Calcium and Magnesium (together)	mg/kg	max. 5	EN 14538
Flashpoint	°C	min. 93	ASTM D 93
Water and sediments	Vol.%	max. 0.05	ASTM D 2709
Kinematic viscosity at 40 °C	mm^2/s	1,9 - 6,0	ASTM D 445
Ash content (Sulphate ash)	Weight%	max. 0.02	ASTM D 874
Sulphur content	Weight%	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	Weight%	max. 0.050	ASTM D 4530
Acid number	mg KOH/g	max. 0.50	ASTM D 664
content of free glycerine	Weight%	0,020	ASTM D 6584
content of total glycerine	Weight%	0,240	ASTM D 6584
phosphor content	Weight%	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 6751-07a Grade S 15

** ASTM D 6751-07a Grade S 500

Appendix 16:
Fuel specification (requirements, test method and limit values)
Rape seed fuel according to pre-standard DIN V 51605

Properties	Units	Limit values DIN V 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. 220	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. 39	Value from experience
Coke residue	% (m/m)	max. 0.40	EN ISO 10370
Iodine number	g Iodine / 100g	min. 95 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. 12	EN 14107
Calcium and Magnesium (together)	mg/kg	max. 20	EN 14538
Ash content (oxide ash)	% (m/m)	max. 0.01	EN ISO 6245
Water content	% (m/m)	max. 0.075	EN ISO 12937