Approval specifications of fuels and lubricants for DEUTZ engines
Freigabespezifikationen von Kraft- und Schmierstoffen für DEUTZ-Motoren

Joachim Joisten-Pieritz, Markus Winkler
UNITI Mineral Oil Technology Congress, Stuttgart (4th April 2017)

The engine company.
Agenda

- DEUTZ AG – the engine company
- Fuel specifications for DEUTZ engines
- Lubricant specifications for DEUTZ engines
- Summary and outlook
DEUTZ at a glance

Company profile
- Founded in 1864 by N.A. Otto, the developer of the four stroke engine
- Independent manufacturer of diesel and gas engines in the 25 to 520 kw power range
- Worldwide sales channels and service network
- Leading technology and high-quality products
- Blue ship customer base

Segments
- DEUTZ Compact Engines: liquid cooled engines < 8 litres engine displacement
- DEUTZ Customised Solutions: liquid-cooled engines > 8 litres engine displacement and air-cooled engines

Financials 2016
- Revenue €1,260.2 million
- EBIT €23.4 million
- Equity ratio 46.3%

Management board
- Dr Frank Hiller (CEO)
- Dr Margarete Haase (CFO)
- Michael Wellenzohn (CSO)
## Key applications

<table>
<thead>
<tr>
<th>Construction equipment</th>
<th>Typical application</th>
<th>Markets benefit from macro trends</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Excavator, Wheel loader, Paver Underground mining</td>
<td><img src="image1" alt="Image" /> <img src="image2" alt="Image" /></td>
</tr>
</tbody>
</table>

| Material handling      | Forklift truck, Telehandler Aerial work platform Ground support | ![Image](image3) ![Image](image4) |

| Agricultural machinery | Tractor Harvester | ![Image](image5) ![Image](image6) |

| Stationary equipment   | Genset Pump Compressor | ![Image](image7) ![Image](image8) |

| Automotive             | Rolling stock Special vehicle Truck & Bus | ![Image](image9) ![Image](image10) |

→ **DEUTZ engines serve a broad range of applications**
DEUTZ customer base and applications

Your partner on the road ahead

VE-TA1 · Winkler 29.03.2017

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Competitive product features: compact size, low fuel consumption, smart exhaust after-treatment

DEUTZ engine portfolio will satisfy the future EU emissions standard announced for 2019 “EU Stage V”

Expanding product range for EU Stage V emissions standard in 2019:

- New 3-cylinder TCD 2.2 on same platform with 4-cylinder TCD 2.9; both engines will also be available as gas versions (LPG)
- New 4-cylinder TCD 5.0 to gain market share in the 100 to 150kW output range
- DEUTZ intends to expand its product portfolio in the 200 to 700 kW power output range with engines supplied by Liebherr that will be sold under the DEUTZ brand
Compliance with new emission standards requires substantial R&D investments and know-how.

Both the costs of implementing the required technology and the timing of new emission regulation put substantial strain on engine manufacturers.

DEUTZ is at the forefront of emission reduction technology on the basis of internal and external systems.

From 1999 till 2019 NOx was reduced by 95.7% and particle emissions by 97.9%.
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Fuel specifications for DEUTZ engines

**Engine**
- Basic engine (metallic material, elastomers ….)
- Emission / combustion matching
- Fuel injection system
- Exhaust aftertreatment system

**Legislation / Market**
- Legal requirements
- Tax / Tax benefits
- Specified / recommended fuels
- Fuel price

**Customer**
- Engine application
- Engine operation manual
- Documentation
- Warranty
- Acceptance of customers

**Influence on Fuel Quality**
Fuel specifications for DEUTZ engines

- Relevant fuels for DEUTZ engine applications
  - Diesel fuel
  - “Tax-reduced” Diesel fuels (heating oil) and off-road Diesel fuels
  - Paraffinic Diesel fuel
  - Biodiesel and Diesel-/Biodieselblends
  - Liquefied petroleum gas (LPG)
  - Additionally with lower significance:
    - Kerosene (F-34 / F-63)

- All approved fuels and applications are published in technical circular „Fuels“ (TR 0199-99-01218/3)
Fuel specifications for DEUTZ engines

- **Diesel fuel**
  - Approved for **EN 590** (Europe) and **ASTM D 975** (US market)
  - Biodiesel content max. B7 in Europe or max. B5 in US
  - Emission Downgrade Engines (EDG engines) without EAT and ecEGR ➔ Sulfur max. 500 mg/kg

- **Tax-reduced Diesel fuels (heating oil) and off-road Diesel fuels**
  - Mostly red marked with directly tax benefit at filling station (e.g. France)
  - Heating oil for stationary gensets (power generation) in Germany allowed
  - Off-road fuels according **EN 590 quality** (sulphur, lubricity, density) or **DIN 51603-1** (low sulphur quality)

- **Engines with exhaust gas aftertreatment systems (EAT) from Emission Stage IIIIB or Tier 4 interim onwards can only be operated with sulphur-free fuels**
  - EU: max. 10 mg/kg Sulphur
  - US: max. 15 mg/kg Sulphur
Fuel specifications for DEUTZ engines

- Paraffinic diesel fuel (XtL)
  - Synthetic production from natural gas (GtL – Gas to Liquid) or vegetable oils (HVO – hydrogenated vegetable oils), also from coal (CtL – Coal to Liquid) and biomass (BtL – Biomass to Liquid) possible
  - Blending of paraffinic diesel in diesel fuel according EN 590 possible, if all limits of diesel are fulfilled

- Future path for sustainable fuel: production by regenerative electricity ➔ PtL – Power to Liquid

- DEUTZ engines without EAT are approved

- Approval for DEUTZ engines with EAT are in process
Fuel specifications for DEUTZ engines

- Biodiesel (Fatty Acid Methyl Ester – „FAME“)
  - Important for reduction of green house gases
  - Tax-reduced in different countries and for special applications
  - 100% Biodiesel: EN 14214
  - Diesel-/Biodieselblends > B7 up to B30
    - EN 16734 (B10), EN 16709 (B20/B30), ASTM D 7467 (B20)
  - Approved for almost all engine families without EAT
  - Limited approval for agricultural engines for emission level EU Stage IIIB
  - Restrictions for storing and handling Biodiesel and Biodieselblends are published in TR 0199-99-01218

- Research project in cooperation with University Rostock
  - “Emission behavior of industrial and agricultural engines in EU COM IV/V applications with exhaust aftertreatment for release of Biodiesel (B100) and Biodieselblends”
  - Project scheduled until autumn 2017
Fuel specifications for DEUTZ engines

- **Liquefied petroleum gas (LPG)**
  - New DEUTZ gas engines are under development for EU Stage V
    - G 2.2 and G 2.9 for material handling applications
  - **EN 589** Mixture of C₃-/C₄-hydrocarbons (filling station quality)
    - New draft is ongoing (prEN 589:2016-11)
  - **DIN 51622** Mixture of C₃-/C₄-hydrocarbons
    - min: 95% Propane-/Propene-isomers or 95% Butane-/Butene-isomers
    - Typically DIN 51622 quality is used in the European market for material handling applications
  - **ASTM D 1835** Standard Specification for liquefied petroleum gases for the US market
  - Bio-LPG can be also used
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■ Lubricant specifications for DEUTZ engines

■ Summary and outlook
Lubricant specifications for DEUTZ engines

■ Reasons for introducing new specification for lube oils
  ● New emission levels
  ● Increased demands on engines with regard to component temperatures, performance density, prolonged oil change intervals and reduced oil refilling volumes
    ➔ Engine oils are very important construction elements

■ Introduction of DEUTZ Quality Class oil approval system in May 2007
  ● In-house spec H685-3 „DEUTZ lubricating oil Quality Classes DQC”

■ Introduction of a monthly updated oil approval list on DEUTZ homepage
  ● http://www.deutz.com/service/maintenance/operating_liquids/oils/deutz_quality_class.en.html
  ● DEUTZ has registered DQC as trademark in Germany, the European Union and USA
Lubricant specifications for DEUTZ engines

- Update in February 2011
  - Subdivision in conventional oils and oils based on low SAPS technology for engine with exhaust aftertreatment systems
  - Implementation of new API and ACEA tests (new engines tests, physical-chemical parameters)

- Introduction of a special approval oil list for engines with steel pistons in 2016
  - Engine families TTCD 6.1 and TTCD 7.8
  - Limits: OM 501LA-Test piston cleanliness ≥ 34 merits, DQC IV-10 LA
  - Every oil which fulfills these requirements is published in a special oil approval list
Lubricant specifications for DEUTZ engines

<table>
<thead>
<tr>
<th>DEUTZ Quality Class</th>
<th>Performance Level</th>
<th>Corresponding ACEA / API category</th>
</tr>
</thead>
<tbody>
<tr>
<td>DQC I-02</td>
<td>Minimum oil quality, some shorter oil change intervals</td>
<td>ACEA E2 or API CF/CF-4</td>
</tr>
<tr>
<td>DQC II-10</td>
<td>Standard quality, usually used in engines with open crankcase ventilation</td>
<td>ACEA E2/E4/E5/E7 or API CG-4/CH-4/CI-4/CI-4 plus</td>
</tr>
<tr>
<td>DQC III-10</td>
<td>High performance diesel engine oil, application for engines with closed crankcase ventilation and/or with high thermal loads</td>
<td>ACEA E4-12 / E7-12 + Extra requirements</td>
</tr>
<tr>
<td>DQC IV-10</td>
<td>Ultra high performance diesel engine oil for engines with highest level of output with closed crankcase ventilation and/or with the highest thermal loads</td>
<td>ACEA E4-12 + Extra requirements</td>
</tr>
<tr>
<td>DQC II-10 LA</td>
<td><strong>Low-ash</strong> diesel engine oil, standard quality, usually used in engines with open crankcase ventilation</td>
<td>ACEA E6-12 / E9-12 or API CJ-4</td>
</tr>
<tr>
<td>DQC III-10 LA</td>
<td><strong>Low-ash</strong> high performance diesel engine oil, application for engines with closed crankcase ventilation and/or with high thermal loads</td>
<td>ACEA E9-12 or API CJ-4 + Extra requirements</td>
</tr>
<tr>
<td>DQC IV-10 LA</td>
<td><strong>Low-ash</strong> ultra high performance diesel engine oil for engines with highest level of output with closed crankcase ventilation and/or with the highest thermal loads</td>
<td>ACEA E6-12 + Extra requirements</td>
</tr>
</tbody>
</table>

- Engines oils approved according to higher DQC classes may also be used in the application requiring lower oil classes.
- Low SAPS oils can also be used in engines without EAT, if the sulphur content in fuel is not higher than 50 mg/kg.
- DQC II-05, DQC III-05 and DQC IV-05 are invalid since February 2014.
Lubricant specifications for DEUTZ engines

- All recommendations for engine oils are published in the technical circular „Lubricating oil“ (TR 0199-99-01217/2)
  - DEUTZ lubricating oil recommendations
  - Oil quality ➔ DQC-System
  - Viscosity classes
  - Charts with oil change intervals for all DEUTZ engine families and engine loads
  - Remarks for using low SAPS oils for engines with exhaust after treatment systems
Lubricant specifications for DEUTZ engines

The US EPA Tier 4 Interim and EU Stage IIIB emission standards and the necessary exhaust gas after-treatment - together with increased demands on units in terms of temperature, power density, prolonged oil change intervals and lower oil consumption - required an update of the existing oil release classes as well as the inclusion of the new DEUTZ Quality Class (DQC) for low-ash engine oils / low SAPS oils.

<table>
<thead>
<tr>
<th>Quality Class</th>
<th>Oil type</th>
</tr>
</thead>
<tbody>
<tr>
<td>DQC I-02</td>
<td>Minimum oil quality, some shorter oil change intervals</td>
</tr>
<tr>
<td>DQC II-10</td>
<td>Standard quality, usually used in engines with open crankcase ventilation</td>
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<td>DQC III-10</td>
<td>High performance diesel engine oil, application for engines with closed crankcase ventilation and/or with high thermal loads</td>
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<tr>
<td>DQC III-10 LA</td>
<td>Low-ash diesel engine oil, standard quality, usually used in engines with open</td>
</tr>
</tbody>
</table>

Applications for DQC Releases

The links on this page provide the lube oil producers with the opportunity to download the DEUTZ AG company standard for DQC releases together with the appendices (limit values and application forms). In the company standard, the formats of the release procedure are also described.

Please note: DEUTZ is the sole owner of the trademark DQC, which is protected in Germany and worldwide. All rights and claims in respect of the brand remain with DEUTZ DQC.

If you have any questions concerning lubricant releases, please contact us at lubrants.de@deutz.com.

Further information and the monthly updated release list for download can be found here:

- Technical Circular Lubricants
- Company Standard (Feb. 2011)
- Appendix A
- Appendix B
- Appendix C
- Form for Release Issue valid from 01.01.2014
- DQC Release List Issue 01/2017
- DQC Release List Issue for TDCi engines 01/2017

Homepage: www.deutz.com >> Service >> Operating Liquids >> Oils >> Deutz Quality Class
DEUTZ roadmap for future lubricant specifications – Challenges for the future

- New emission level for the EU market ➔ EU Stage V
- New oil specifications for the US market (PC-11 ➔ API CK-4) and Europe market (ACEA E4-16, E6-16, E7-16, E9-16)
- Fuel economy oils are less important for the DEUTZ business (construction equipment, agricultural engines, gen sets) than for trucks and passenger cars, but...
- …the plan for the next generations of engines (like TCD 5.0, TCD 2.2) is to implement FE oils (HTHS-Viscosity ≥ 2.9 mPas) in the specifications and an in-house spec for suppliers
- Requirements for larger lube change intervals for Tier 4 or EU Stage IV/V engines
  - 500 h ➔ 1000 h
- The most important oil classes for today’s and future DEUTZ engines are DQC III and DQC III LA and higher
- DEUTZ engines, which are running with LPG, will be implemented in our oil approval list ➔ min. DQC III LA quality level
DEUTZ roadmap for future lubricant specifications – Proposed changes and updates in the new DEUTZ in-house specification

- Same limits like in the current spec for the following requirements (DQC III LA / DQC IV LA)
  - Evaporation loss CEC L-040-93 (Noack) $\leq 12 / 11 \%$
  - Oxidation induction time CEC L-085-99 $\geq 70 / 110 \text{ min}$
  - Corrosion ASTM D 6594 $\leq 90 / 70 \text{ ppm}$
  - MTU deposit test DIN 51535 $\leq 110 \text{ mg} / 90 \text{ mg}$

- Implementation of new laboratory tests
  - Oil Oxidation with Biodiesel (CEC L-109-12)
  - Oil / elastomer compatibility tests (RE6, RE7, RE8, RE8) (CEC L-112-16)

- Implementation of new engine tests
  - Biofuel impacted Piston Cleanliness and Engine Sludge – OM 646 LA Bio (CEC L-104-16)
  - Alternative for Mack T-12 $\rightarrow$ Mack T-13

- Deletion of the old “alternative” engines tests for wear (OM 602 A), piston cleanliness OM 441 LA, soot-induced wear Cummins M11 EGR or M11, wear Mack T-10

- Piston cleanliness OM 501 LA Merits must be higher than the regular ACEA-Value of min. 26 only for DQC IV LA level (CEC L-101-08)
## DEUTZ roadmap for future lubricant specifications

### Conventionel technology ➔ engines without EAT up to emission level EU Stage IIIA / Tier 3

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<th>Corresponding ACEA / API category</th>
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<tr>
<td>DQC I-02</td>
<td>Minimum oil quality, some shorter oil change intervals <em>(Note: No change)</em></td>
<td>ACEA E2 or API CF/CF-4</td>
</tr>
<tr>
<td>DQC II-18</td>
<td>Standard quality, usually used in engines with open crankcase ventilation</td>
<td>ACEA E2/E4/E5/E7 or API CG-4/CH-4/CI-4/CI-4 plus</td>
</tr>
<tr>
<td>DQC III-18</td>
<td>High performance diesel engine oil, application for engines with closed crankcase ventilation and/or with high thermal loads</td>
<td>ACEA E4-16 / E7-16 + Extra requirements</td>
</tr>
<tr>
<td>DQC IV-18</td>
<td>Ultra high performance diesel engine oil for engines with highest level of output with closed crankcase ventilation and/or with the highest thermal loads</td>
<td>ACEA E4-16 + Extra requirements</td>
</tr>
</tbody>
</table>
DEUTZ roadmap for future lubricant specifications

Low SAPS Technology ➔ all engines with EAT  (EU Stage IIIB / Tier 4 interim and higher)

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</thead>
<tbody>
<tr>
<td>DQC II-18 LA</td>
<td>Standard quality, usually used in engines with open crankcase ventilation</td>
<td>ACEA E6-16 / E9-16 or API CJ-4</td>
</tr>
<tr>
<td>DQC III-18 LA</td>
<td>High performance diesel engine oil, application for engines with closed crankcase ventilation and/or with high thermal loads</td>
<td>ACEA E9-16 or API CJ-4 / CK-4 + Extra requirements</td>
</tr>
<tr>
<td>DQC IV-18 LA</td>
<td>Ultra high performance diesel engine oil for engines with highest level of output with closed crankcase ventilation and/or with the highest thermal loads</td>
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DEUTZ roadmap for future lubricant specifications

DQC III-18 LA

DQC IV-18 LA
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Summary and outlook – fuels

- DEUTZ supports a large number of liquid and gaseous fuels for national and global markets and different applications

- Appropriate market fuel standards are essential
  - Supporting the emissions requirements/technologies and ensuring legislative compliance
  - Introduction of alternative/regenerative fuels and fuel blends as one option to reduce greenhouse gases and the global warming
  - Introduction of better fuels standards to reduce exhaust emissions like particulates and NOx
  - Ensuring customer satisfaction and warranty

- More international standards should be developed in the longer term
  - Engine industry is a global business
Summary and outlook – lubricants

- DEUTZ has approved a large number of additive formulations and engine oils
  - DEUTZ supports every oil supplier requesting DQC approval
  - DEUTZ expects oil suppliers to only offer approved DQC oil qualities to DEUTZ customers and OEMs

- DEUTZ will update DEUTZ DQC oil approval system until end of 2017
  - Important technologies for the future: low SAPS oils (EU Stage IV/V and Tier 4f)
  - The most important oil classes for DEUTZ engines are DQC III-10 LA and higher
  - Increased requirements for lube change intervals engines Tier 4 and EU Stage IV/V
  - LPG engines will be included in the DEUTZ approval list → DQC III-LA quality or higher
  - Fuel economy oils are currently less important for the DEUTZ business (construction equipment, agricultural engines, gensets) than for the truck business
  - Medium-term plan → Implementation of Fuel Economy oils (HTHS-Viscosity ≥ 2.9 mPas) in the specifications and an in-house spec for DEUTZ suppliers for the next generations of engines
Thank you for your attention!

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