

Specification Requirements on Synthetic Diesel Fuel from the Perspective of a FIE Manufacturer

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2. Design of Common Rail System and components
3. Characteristics of typical Diesel fuels and impact on the fuel injection system
4. Impact on engine application and calibration
5. Summary and conclusions

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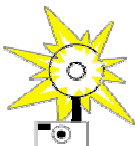
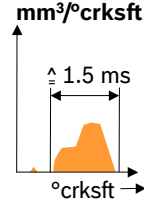
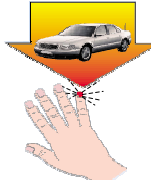

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Boundary conditions of Diesel high press. injection

injection time	injection characteristic	injection pressure	min. injection quantities	injection frequency
1.5 ms	mm³/°crksft	2000 bar	1 mm³/stroke	16000 cycles/min. @ 250 Hz
				

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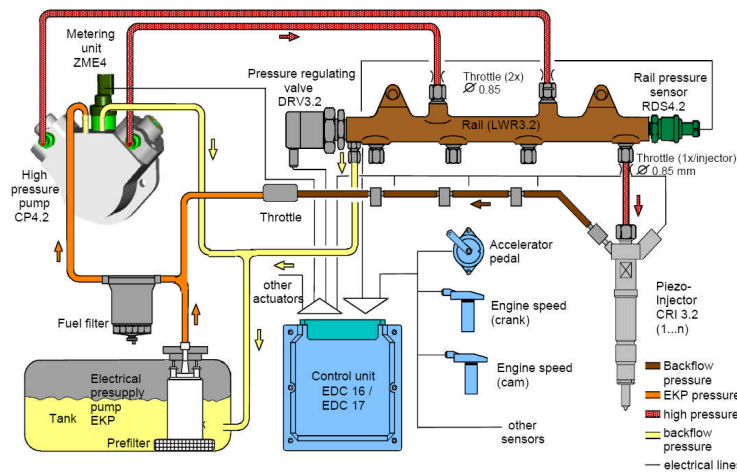
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Design of Common Rail System (RB 3. Gen.)



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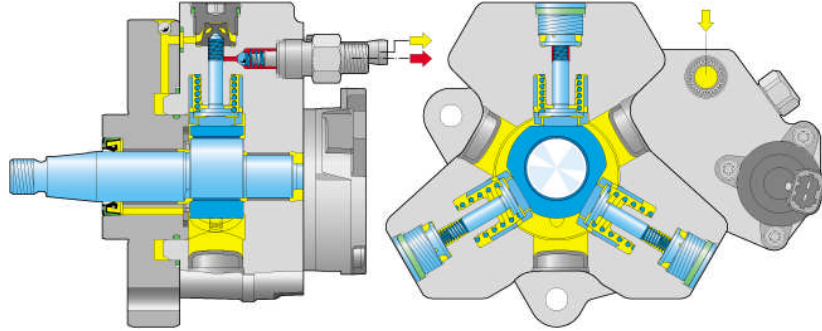
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Common Rail High Pressure Pump (RB CP3.2)



■ high pressure
■ low pressure

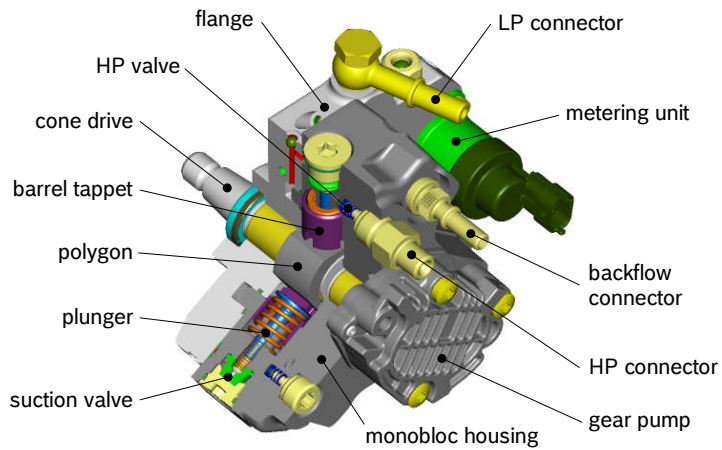
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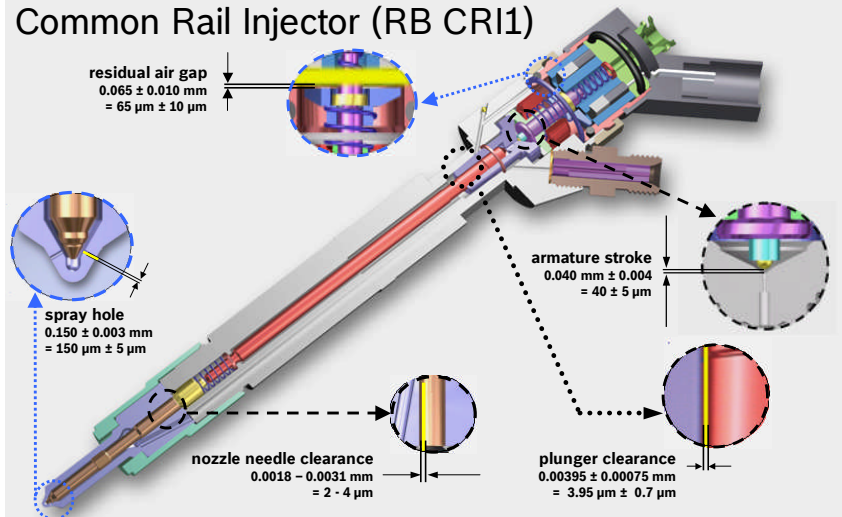
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Common Rail Injector (RB CRI1)



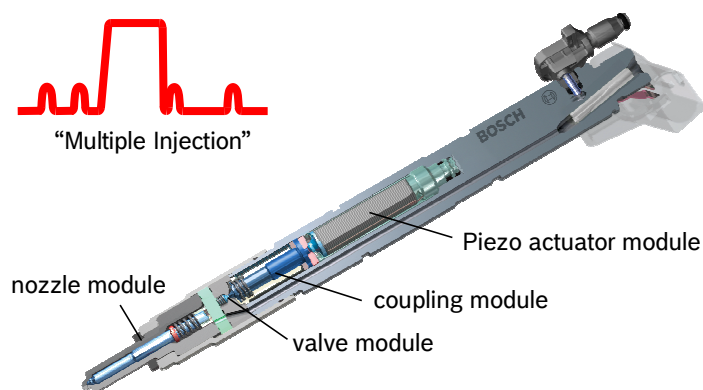
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Common Rail Injector (RB Piezo Inline Injector)



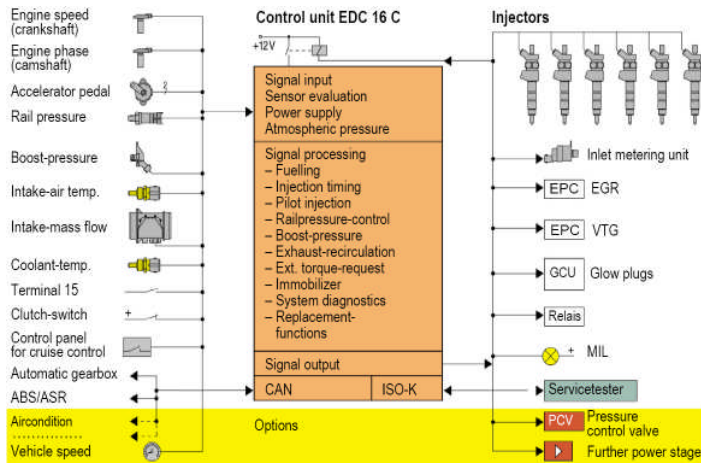
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Engine control with Common Rail System



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Criteria for Good Diesel Fuel Quality (according to ACEA World-Wide Fuel Charter)

1. For Combustion, Efficiency and Emissions

- Cetane number ≥ 55
- Total aromatics $\leq 15\%$
- Polycyclic aromatics $\leq 2\%$
- Sulphur content ≤ 10 ppm

2. For Function and Durability of FIE

- Lubricity, HFRR ≤ 460 μm
- Dirt / Particles ≤ 10 mg/kg (total contamination)
- Water ≤ 200 mg/kg, no free water
- No admixtures (FAME $> 5\%$, alcohol, ...)

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Overview of Standardized Fuel Characteristics

properties	unit	Diesel EN 590 (2005)	Diesel (typical german quality 2005/2006)	SynFuels (Bosch investigated samples)	FAME EN 14214 (2003)
cetane number		≥ 51	49.6 ... 53.3	58 ... 80	≥ 51
density 15°C	kg/m ³	820 ... 845	821.3 ... 838.2	770 ... 800	860 ... 900
total aromatics	% (m/m)	-	18.1 ... 26.5	< 0.1	- (< 0.1)
poly aromatics	% (m/m)	≤ 11	1.1 ... 4.1	< 0.1	- (< 0.1)
sulfur content	mg/kg	≤ 50 2009: ≤ 10	4 ... 17	≤ 2	≤ 10
water content	mg/kg	≤ 200	7 ... 114	7 ... 26	≤ 500
oxidation stability					
- EN 12205 sludge	g/m ³	≤ 25	1 ... 5	1 ... 91	-
- EN 14112 induction period	h	-	13 ... >48	13 ... >48	≥ 6.0
lubricity	μm	≤ 460	205 ... 434	330 ... 580 *	- (≤ 460)
viscosity 40°C	mm ² /s	2.0 ... 4.5	2.3 ... 3.4	2.6 ... 3.5	3.5 ... 5.0
FAME content	% (v/v)	≤ 5.0	< 0.1 ... 5.0	< 0.1	≥ 96.5
distillation		see distillation curve			

* without lubricity additive

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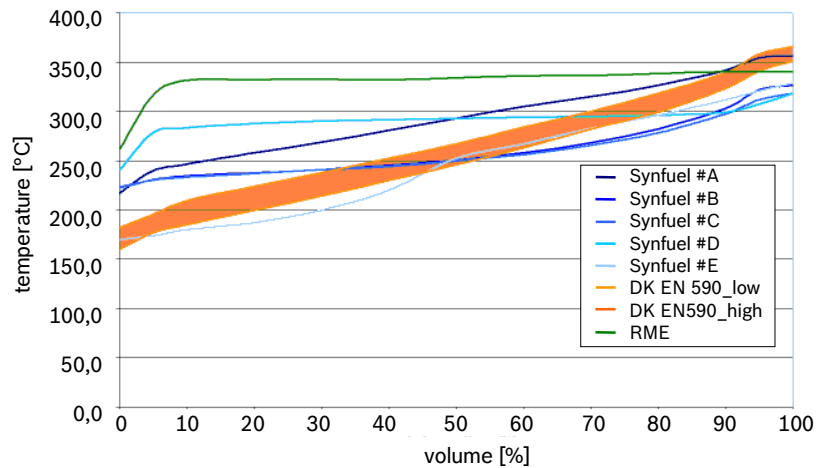
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Distillation Curves of Synthetic Diesel Fuels



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Impact of Fuel Properties on the Injection System (1)

- high cetane number
 - shorter ignition delay*

- lower density
 - fuel mass injected reduced by 5 % because of volume metering characteristic of Common Rail System
 - partly compensated by 3 % higher energy content per mass (not standardized)
 - ⇒ operation set points in ECU shifted by 2 % with respect to injected fuel energy*

* eventually to be compensated by changed calibration

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Impact of Fuel Properties on the Injection System (2)

- sludge
 - too high in one sample (accompanied by high acidity)
 - to be below EN590 standard
 - to be replaced or complemented by induction period

 - low lubricity
 - to be adjusted to necessary level for wear avoidance by appropriate additivation

 - higher distillation curve
 - influence on evaporation and mixture formation in cylinder*
- * eventually to be compensated by changed calibration

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Impacts of non-standardized Fuel Properties

- risk of cavitation and wear by higher volatility and lower density
- fuel behaviour at low and high temperature
- acid formation during ageing process
- additive compatibility
- elastomer compatibility with used NBR-sealings of older vehicles

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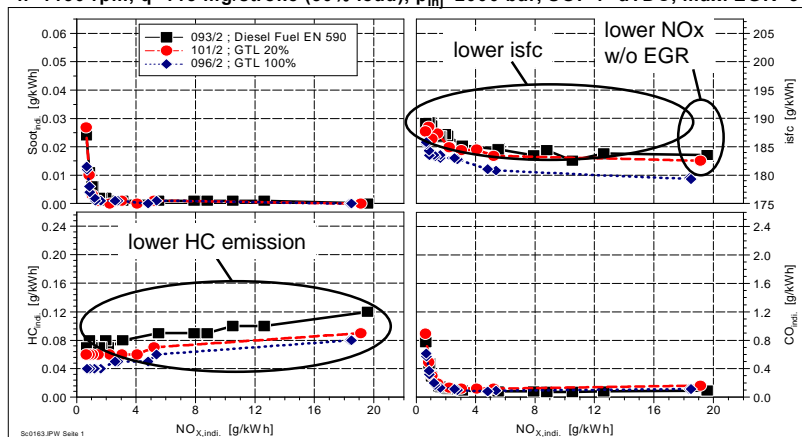


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Part Load Behaviour of a Modern CV Engine (1)

$n=1130$ rpm, $q=115$ mg/stroke (50% load), $p_{inj}=2000$ bar, $SOI=1^\circ$ aTDC, max. EGR=36%



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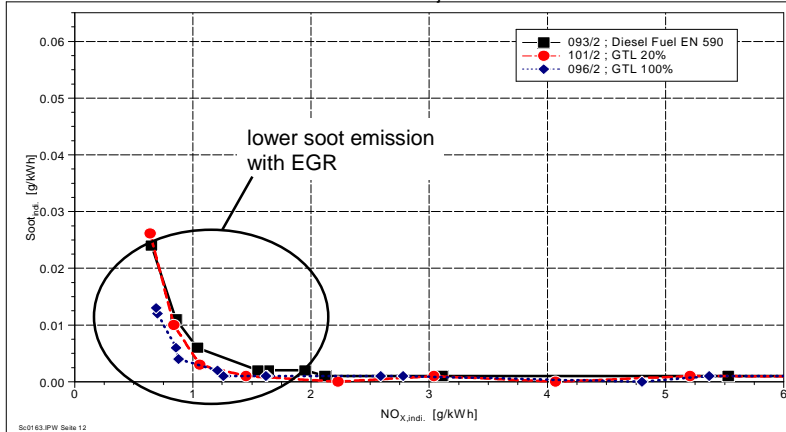


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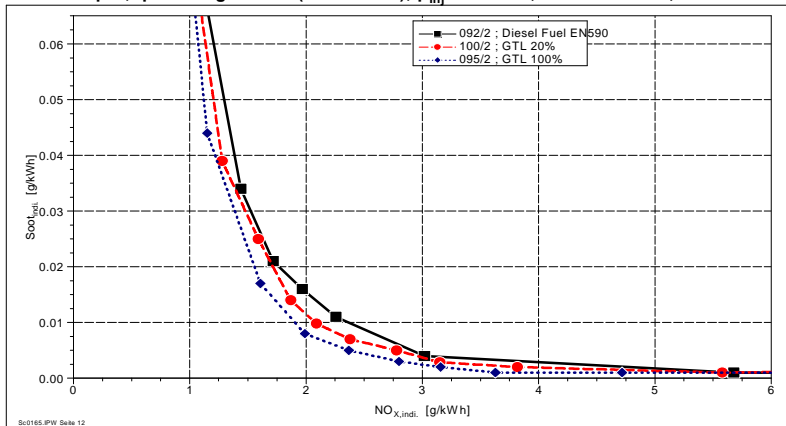


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Full Load Behaviour of a Modern CV Engine

n=1710 rpm, q=213 mg/stroke (100% load), p_{inj}=2400bar, SOI=-1° aTDC, max. EGR=30%



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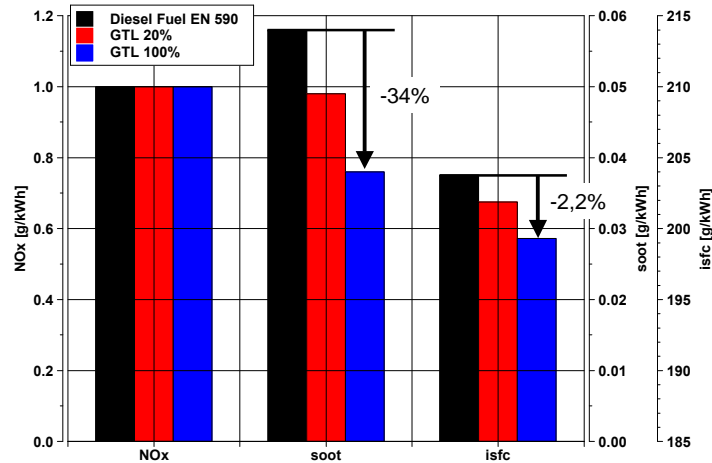
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ESC Test Result Estimation at NO_x=1g/kWh



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Summary / Conclusions

- XtL Diesel Fuel exhibits properties largely in compliance with the demands of a modern fuel injection system, but partly different to Diesel according to EN590 (density) or field quality (cetane number)
- combustion related properties are better than those of conventional Diesel due to different molecular structure of components
- for optimum results an adaption of engine calibration is necessary when pure GtL is used
- for low blend rates no calibration adaption is necessary, but lower advantages to be expected under these conditions (preferred short and mid-term solution from Bosch point of view)
- for an area-wide release intensive fleet testing is necessary to assure long term durability of the injection equipment
- XtL to offer chance for comprehensive optimization of engine, FIE and fuel for homogeneous Diesel combustion processes

