The following tables summarize the impacts of various diesel fuel qualities on emissions from light and heavy duty diesel vehicles, respectively.

Impact of Fuels on Light Duty Diesel Vehicles

Diesel Fuel Characteristic	Pre-Euro	Euro 1	Euro 2	Euro 3	Euro 4	Euro 5[1]	Comments
Sulfur↑	SO_2, PM↑		If ox cat, SO_3, SO_2, PM↑		If Filter, 50 ppm maximum, 10-15 ppm better		If NOx adsorber used requires near zero sulfur (<10 ppm) With low S, use lubricity additives
Cetane↑	Lower CO, HC, benzene, 1,3 butadiene, formaldehyde & acetaldehyde						Higher white smoke with low cetane fuels
Density↓	PM, HC, CO, formaldehyde, acetaldehyde & benzene↓, NOx↑						
Volatility (T95 from 370 to 325 C)	NOx, HC increase, PM, CO decrease						
Polyaromatics↓	NOx, PM, formaldehyde & acetaldehyde↓ but HC, benzene & CO ↑						some studies show that total aromatics are important

1. [1] Euro 5 emissions standards for light duty diesel vehicles have not yet been adopted by the EU. However, the EU Commission has indicated that it will propose these standards during 1995 and they will likely become mandatory during the period from 2008-2010. It seems likely that these standards will mandate the use of PM filters on all light duty diesel vehicles.

Impact of Fuels on Heavy Duty Diesel Vehicles

Diesel	Pre-Euro	Euro 1	Euro 2	Euro 3	Euro 4	Euro 5[2]	Comments
Sulfur↑	SO_2, PM↑		If ox cat, SO_3, SO_2, PM↑		If Filter, 50 ppm maximum, 10-15 ppm better		If NOx adsorber used requires near zero sulfur (<10 ppm) With low S, use lubricity additives
Cetane↑	Lower CO, HC, benzene, 1,3 butadiene, formaldehyde & acetaldehyde						Higher white smoke with low cetane fuels
Density↓	HC, CO ↑, NOx↓						
Volatility (T95 from 370 to 325 C)	Slightly lower NOx but increased HC						Too much heavy ends increases smoke and PM
Polyaromatics↓	NOx, PM, HC ↓						Some studies show that total aromatics are important

2. [2] The EU Commission has also indicated that it will propose Euro 6 emissions standards for heavy duty engines during 2005, likely mandating the use of PM filters on all heavy duty diesel vehicles from 2010 or 2012.

The following tables summarize the impacts of various fuel qualities on emissions from light duty gasoline vehicles.

Impact of Gasoline Composition on Emissions from Light Duty Vehicles

<table>
<tr><th>Gasoline</th><th>No Catalyst</th><th>Euro 1</th><th>Euro 2</th><th>Euro 3</th><th>Euro 4</th><th>Euro 5</th><th>Comments</th></tr>
<tr><td>Lead ↑</td><td>Pb, HC↑</td><td colspan="5">CO, HC, NOx all increase dramatically as catalyst destroyed</td><td></td></tr>
<tr><td>Sulfur ↑ (50 to 450 ppm)</td><td>SO_2 ↑</td><td colspan="5">CO, HC, NOx all increase ~15-20%
SO_2 and SO_3 increase</td><td>MIL light may come on incorrectly</td></tr>
<tr><td>Olefins ↑</td><td colspan="6">Increased 1,3 butadiene, increased HC reactivity, NOx, small increases in HC for Euro 3 and cleaner</td><td>Potential deposit buildup</td></tr>
<tr><td rowspan="2">Aromatics ↑</td><td colspan="6">Increased benzene in exhaust</td><td rowspan="2">Deposits on intake valves and combustion chamber tend to increase</td></tr>
<tr><td>potential increases in HC, NOx</td><td colspan="2">HC↑, NOx↓, CO↑</td><td colspan="3">HC, NOx, CO ↑</td></tr>
<tr><td>Benzene ↑</td><td colspan="6">Increased benzene exhaust and evaporative emissions</td><td></td></tr>
<tr><td>Ethanol ↑ up to 3.5% O_2</td><td>Lower CO, HC, slight NOx increase(when above 2% oxygen content),
Higher aldehydes</td><td colspan="5">Minimal effect with new vehicles equipped with oxygen sensors, adaptive learning systems</td><td>Increased evaporative emissions unless RVP adjusted, potential effects on fuel system components, potential deposit issues, small fuel economy penalty</td></tr>
<tr><td>MTBE ↑ up to 2.7% O_2</td><td>Lower CO, HC, higher aldehydes</td><td colspan="5">Minimal effect with new vehicles equipped with oxygen sensors, adaptive learning systems</td><td>Concerns over Water Contamination</td></tr>
<tr><td>Distillation Characteristics T50, T90↑</td><td>Probably HC↑</td><td colspan="5">HC↑</td><td></td></tr>
<tr><td>MMT ↑</td><td>Increased Manganese</td><td></td><td></td><td>Possible Catalyst</td><td>Likely Catalyst</td><td></td><td>O_2 sensor and OBD may be damaged, MIL</td></tr>
</table>

	Emissions			Plugging	Plugging	light may come on incorrectly
RVP ↑	Increased evaporative HC Emissions					Most critical parameter for Asian countries because of high ambient Temperatures
Deposit control additives ↑		Potential HC, NOx emissions benefits				Help to reduce deposits on fuel injectors, carburetors, intake valves, combustion chamber

Impact of Gasoline Composition on Emissions from Motorcycles

Gasoline	No Catalyst	India 2005	Euro 3	India 2008	Taipei,China Stage 4	Comments
Lead ↑	Pb, HC↑	CO, HC, NOx all increase dramatically as catalyst destroyed				
Sulfur ↑ (50 to 450 ppm)	SO_2 ↑	CO, HC, NOx all increase SO_2 and SO_3 increase				
Olefins ↑	Increased 1,3 butadiene, HC reactivity and NOx					Potential deposit buildup
Aromatics ↑	Increased benzene exhaust					
Benzene ↑	Increased benzene exhaust and evaporative emissions					
Ethanol ↑ up to 3.5% O_2	Lower CO, HC, slight NOx increase	Minimal effect with oxygen sensor equipped vehicles				Increased evaporative emissions unless RVP adjusted, potential effects on fuel system components, potential deposit issues, small fuel economy penalty
MTBE ↑ up to 2.7% O_2	Lower CO, HC	Minimal effect with ox. sensor equipped vehicles				Concerns over Water Contamination small fuel economy penalty
Distillation characteristics T50, T90 ↑	Probably HC↑	HC↑				Not as quantifiable as in passenger cars
MMT ↑	Increased Manganese Emissions	Possible Catalyst Plugging				With low cell density, catalyst plugging risk seems small but there are concerns regarding deposits on spark plugs and in the combustion chamber
RVP ↑	Increased evaporative HC Emissions					
Deposit control additives ↑		potential emissions benefits				Help to reduce deposits on fuel injectors, carburetors