

# Exhaust Emissions



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**BASED UPON S.C. SORENSEN**  
**CHAPTER 6 PART 2**

# Common Exhaust Pollutants



- Unburned Hydrocarbons,  $\text{CH}_x$ , HC's, partially oxidized hydrocarbons, etc.
- Oxides of Nitrogen, NO,  $\text{NO}_2$ ,  $\text{N}_2\text{O}_2$ , etc.
- Carbon Monoxide
- Particulate Matter (soot), soluble, insoluble
- Sulfur and Sulfur Oxides
- Carbon Dioxide

# Diesel Soot Particles

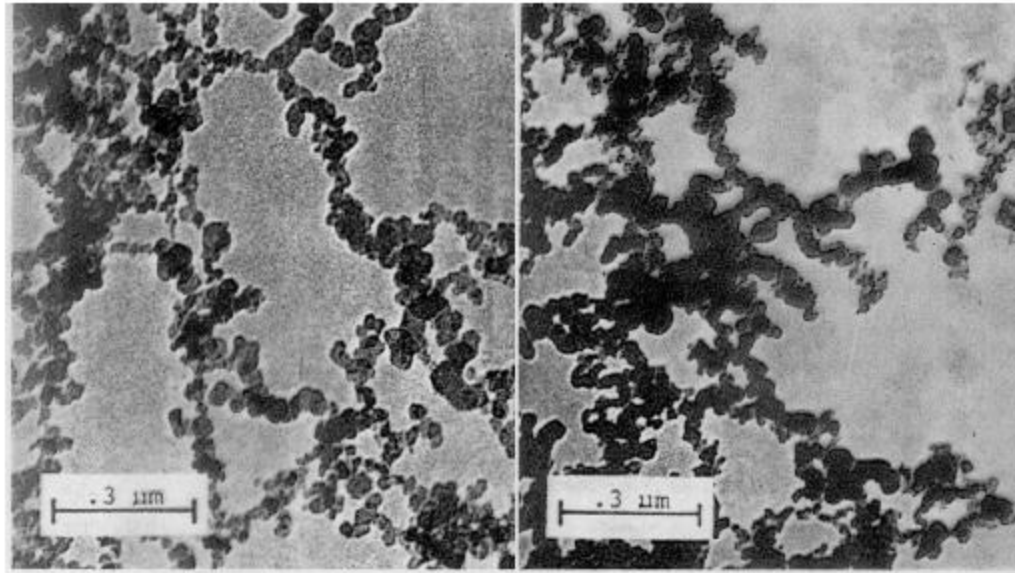


Figure 6.11: Electron microscope pictures of diesel particles. The picture on the left is of particles taken directly from the exhaust pipe, the picture on the right shows particles after the exhaust gas has been diluted with air [68].

# Equilibrium Formation of Solid Carbon

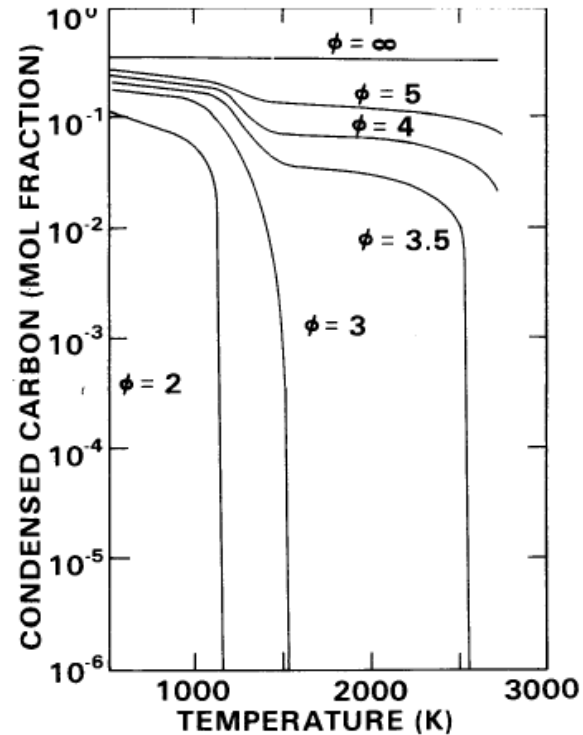


Figure 6.12: The equilibrium formation of solid carbon in the combustion products of a fuel with a H/C ratio of 2.0 at a pressure of 100 atm, as a function of equivalence ratio and temperature [69].

# NO and Soot from CI Engines

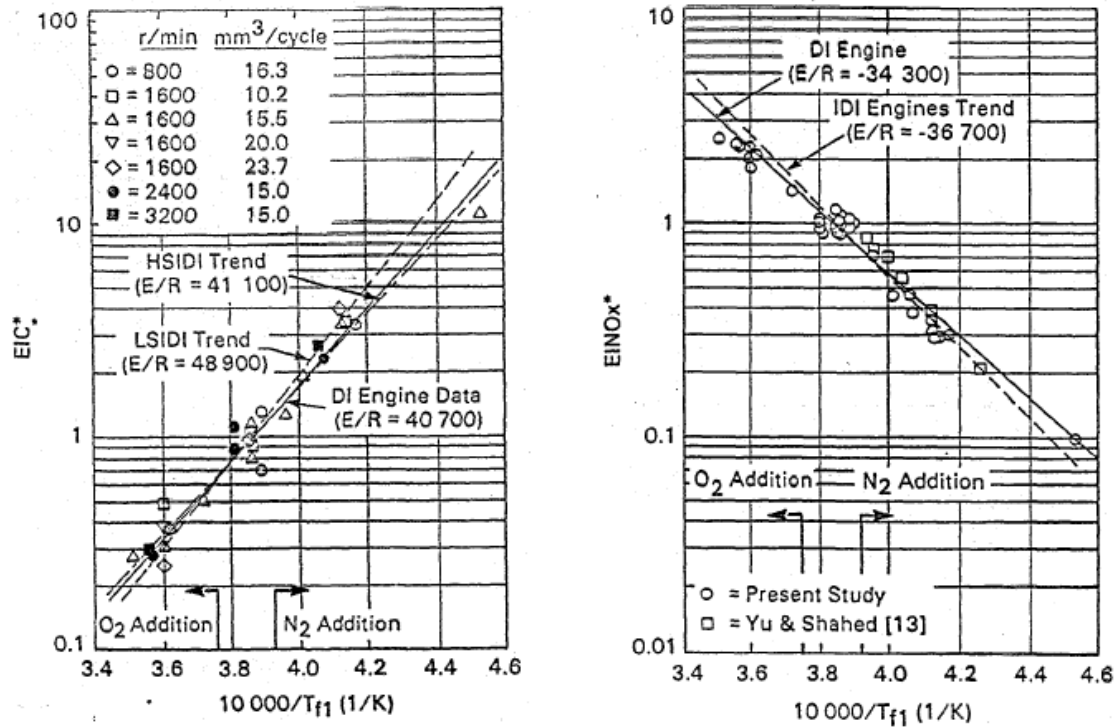


Figure 6.13: The variation of NO and soot emissions from diesel engines as a function of reciprocal flame temperature [69].

# Other Pollutants vs NO<sub>x</sub>

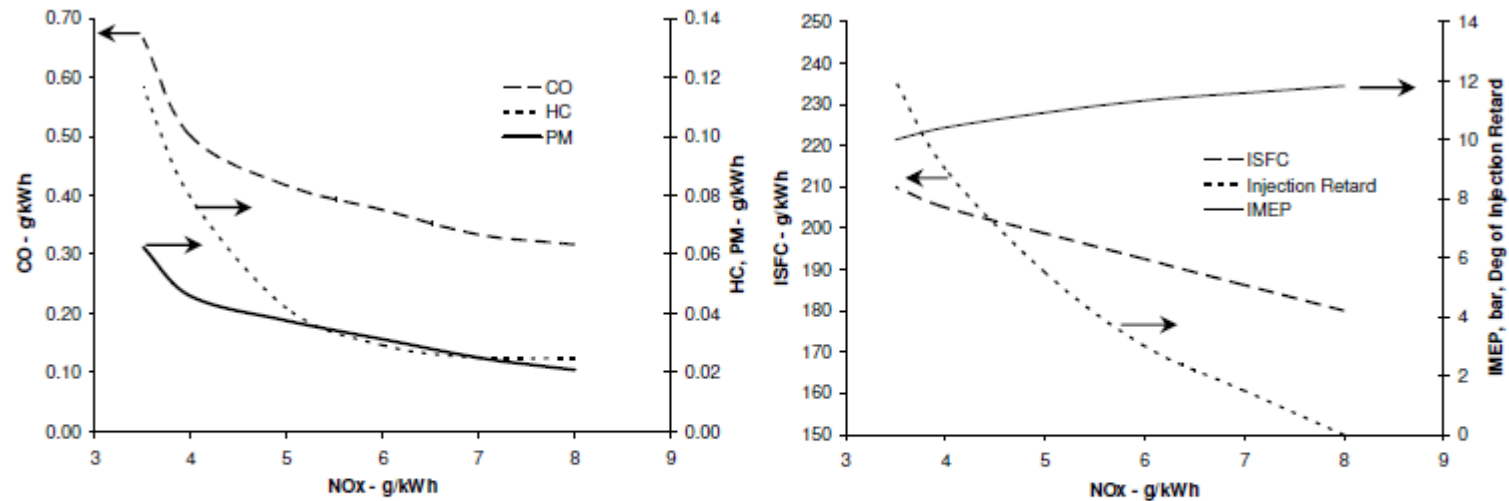


Figure 6.14: Emissions and performance of a heavy duty diesel as a function of NO<sub>x</sub> emission level as the injection timing is retarded at constant speed. From the data of Reference [70].

# Alternate Fuels

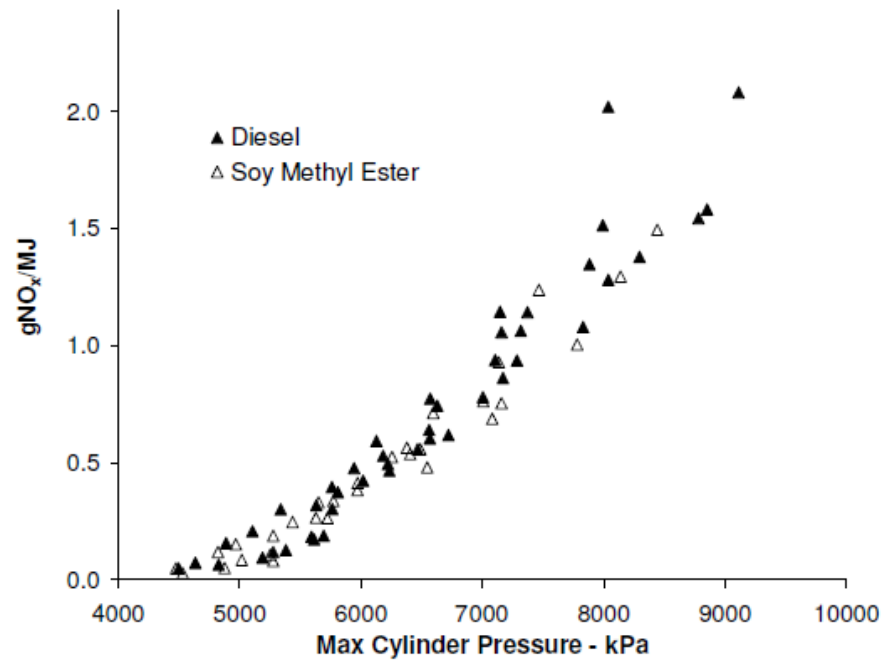


Figure 6.15: The NO<sub>x</sub> emission from a naturally aspirated DI diesel engine as a function of maximum cylinder pressure for diesel fuel and soybean oil methyl ester [48].

# Effect of EGR



Naturally Aspirated

Turbocharged

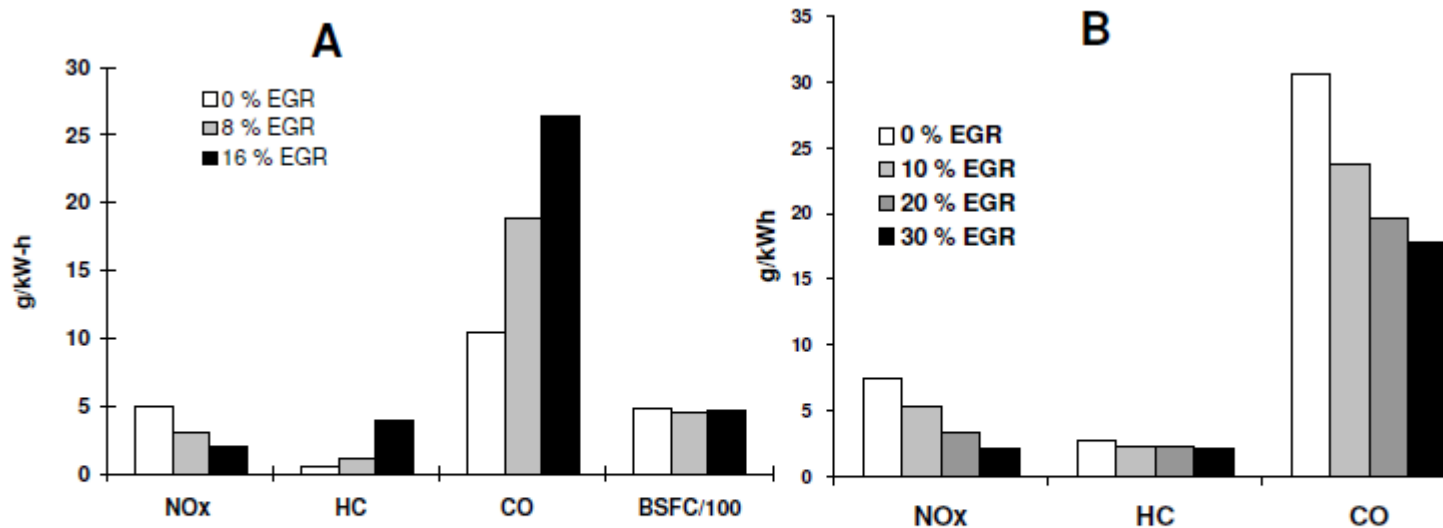


Figure 6.16: The effect of EGR on low load gas phase emissions from: A. A naturally aspirated DI engine operating on dimethyl ether without exhaust gas catalyst, B. A turbocharged, Common rail DI engine, with intake throttling and exhaust gas catalyst operating on diesel fuel.



# Control of Emissions - SCR

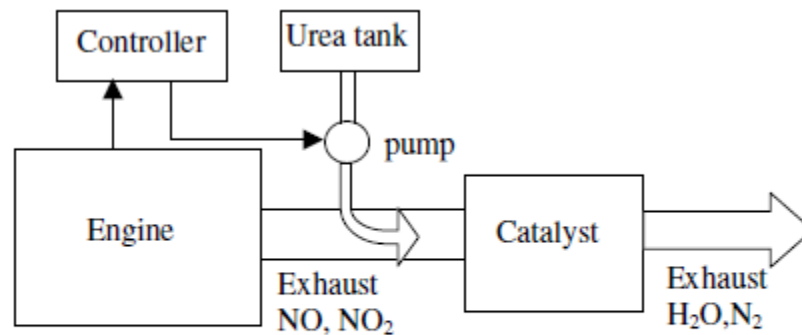


Figure 6.17: A schematic diagram of the selective catalytic reduction system used to reduce NO<sub>x</sub> emissions in diesel exhaust.

# Use of Filtration

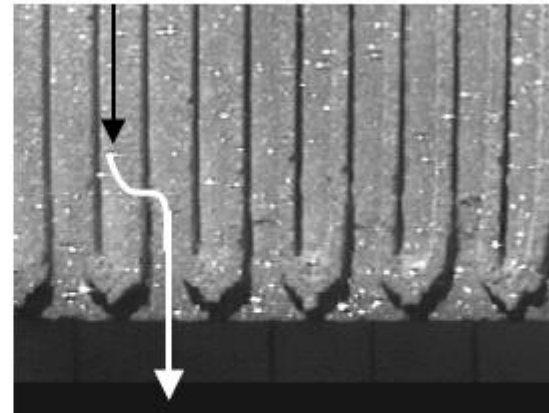
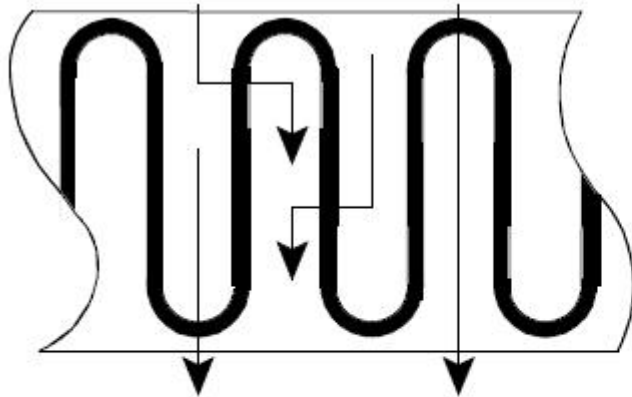


Figure 6.18: A schematic diagram of the principle of a wall flow diesel particle filter (left) and a cutaway photograph of the filter structure showing the closure of alternate flow channels and the flow path through the filter (right).

# Regeneration: Exhaust Temperatures

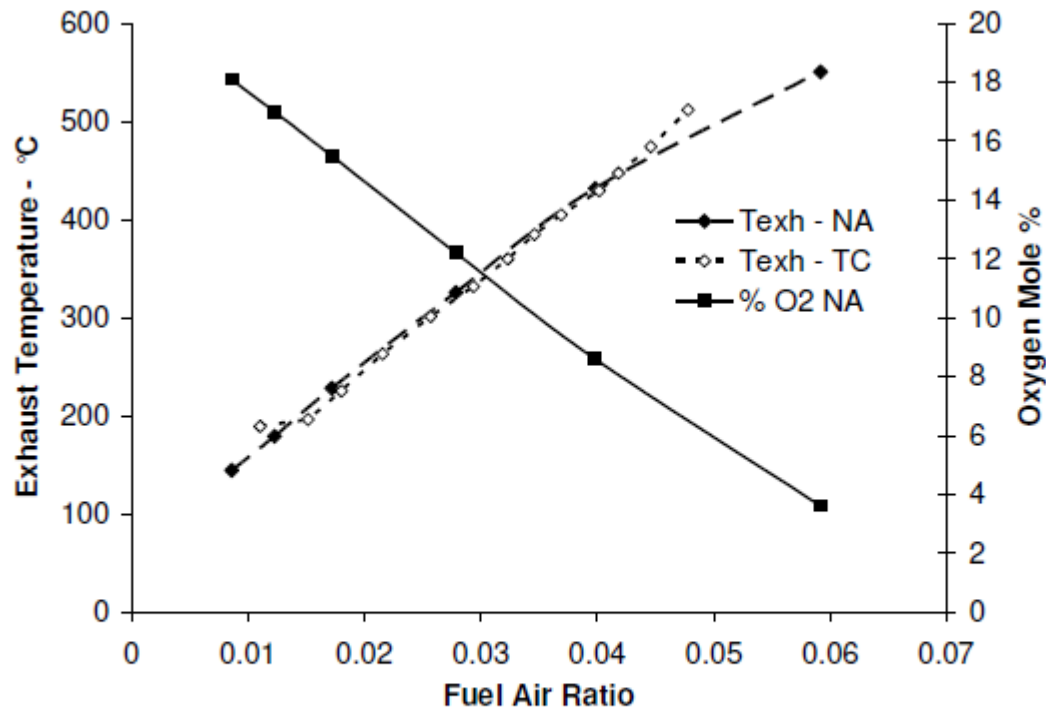


Figure 6.19: Exhaust temperature and Oxygen concentration as a function of fuel air ratio for a naturally aspirated DI diesel engine.

# Filter Materials

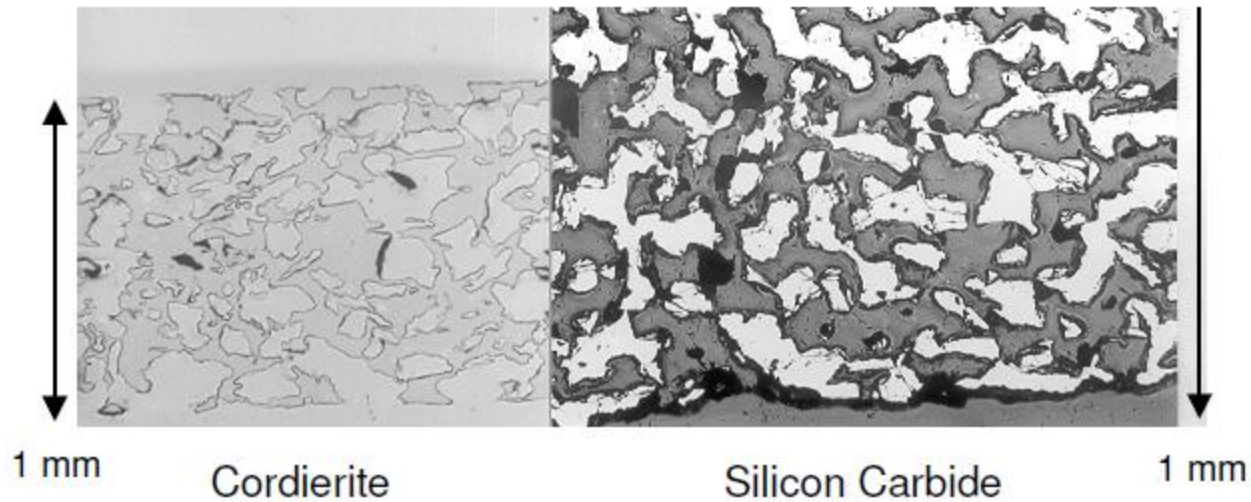


Figure 6.20: The structure of two materials for wall flow diesel particulate filters