Motor Vehicle Emissions
World Wide Achievements
And Challenges For
Exposure Assessment

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U.S. and Euro Light-Duty Vehicle Emission Standards

<table>
<thead>
<tr>
<th>Year</th>
<th>Euro 4</th>
<th>Euro 5</th>
<th>Euro 6</th>
<th>U.S. Tier 2, Bin 5</th>
<th>EPA/CARB</th>
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<tbody>
<tr>
<td>2005</td>
<td>80</td>
<td>60</td>
<td>60</td>
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<tr>
<td>2009</td>
<td>250</td>
<td>180</td>
<td>80</td>
<td>45</td>
<td>12</td>
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<tr>
<td>2014</td>
<td>250</td>
<td>50</td>
<td>45</td>
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<td>12</td>
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<td>62</td>
<td>21</td>
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- **50 ppm S cap**
- **10 ppm S cap**
- **15 ppm S cap** on diesel
- **30 ppm S ave.** on gasoline
- **10 ppm S ave.** on gasoline

Euro 5+ (2011) and 6 include 6 X 10^{11}/km diesel particle number limit;
Phase 1 and 2: HEI 2007 and 2010 Engine ACES Results
Compared to earlier Engines (rigorous 16-hour cycle)

2007 Dramatic Reductions
98% reduction in mass
90% - 99% reduction in Ultrafine Particles, air toxics

2010 Further Reductions
(even compared to 2007)
>90% reduction in NOx
>70% reduction in Particles
More Stringent New Vehicle Emissions Standards Are Spreading Around The World

<table>
<thead>
<tr>
<th>Model Year</th>
<th>2015</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Duty Gasoline Cars</td>
<td>41.4%</td>
<td>78.9%</td>
</tr>
<tr>
<td>Light Duty Diesel Cars</td>
<td>65.4%</td>
<td>87.9%</td>
</tr>
<tr>
<td>Heavy Duty Diesel Trucks</td>
<td>24.9%</td>
<td>78.9%</td>
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</tbody>
</table>
Historical High Growth Has Offset Many Improvements
Vehicles Remain Important Contributor To Local,
Regional and Global Pollution
In Your Face! Literally!
PEMS Testing Results for NOx Diesel Cars in the US

Fortunately Diesel Car Population Is Not Very Large in the US
The Problem is Much More Important in Europe Where Diesel Cars Are Much More Widespread

Fig. 4. Mean hot NOx emission factors of gasoline (left) and diesel (right) passenger cars and light commercial vehicles as a function of model year. Whiskers represent the 95% confidence interval over the mean. Added are the type approval limit values for Euro 1 to Euro 5 passenger cars over the homologation test cycle in force in the respective year. For conversion from limit values in g per km see SI (using measured fuel consumption rates from Hausberger (2010)). For color plot consult online version.
Similar Issues With Heavy Duty Vehicles in Europe
The problem: High off-cycle NOx emissions in urban applications

In-use PEMS testing of Euro IV and Euro V trucks in The Netherlands found emission well above standard in urban driving!

Source: Kleinebrahm 2008
And Europeans are Paying A Health Price
EEA Estimates ~75,000 Premature Deaths Annually
Due to High NO₂ Levels
DPF Removal / Delete

As one of the first companies in the UK to offer DPF Removal we now have years of unmatched knowledge and experience.

**DPF (Diesel Particulate Filter) Removal**

The Removal Procedure

First of all we remove the filter from the exhaust system, unlike other companies we do not fit a simple bypass pipe, this would likely lead to an MOT failure when new MOT regulations are announced. Instead, we modify the original DPF unit, discreetly cutting a small window in the top of the chamber, removing the internal filter before rewelding the window and refitting to the vehicle. This way the vehicle still appears to have a DPF fitted and appears unmodified in anyway.

Once the physical filter removal has been completed the ECU (Electronic Control Unit) is reprogrammed (remapped) and any DPF related structures removed from the vehicles software, this will prevent the vehicle from sensing the missing Filter and will prevent future DPF regeneration and warning lights. This is the most important aspect of the removal process and it is vital that the ECU is reprogrammed correctly or DPF issues will continue.

When carrying out this process we can also remap the ECU for better performance and fuel efficiency, this is normally free of charge with our DPF removal service.

Will removing the DPF result in an MOT failure? No, removing the DPF will have no affect on your MOT.

Removing the DPF from your vehicle is not only a cost effective solution but it also boasts the following advantages:

- Increased performance
- Increased efficiency (MPG)
- Less turbo lag
- Reduced maintenance costs

Call now on 01454 800 117

China Is Now Most Important Motor Vehicle Market

- 2015 – 24.61 M Total Sales
- 21.16 M Light Duty
- 3.45 M Commercial trucks and buses
- Stimulated by 50% tax cut on vehicles with engines 1.6 L or less
- Relatively Few Light Duty Diesels
Vehicle emission characteristics: heavy-duty vehicles

On-road test of buses and trucks showed no improvement in NO$_X$ emission.

**Bus:**
- a) NO$_X$
- b) PM$_{2.5}$

**Truck:**
- a) NO$_X$
- b) PM$_{2.5}$

![Graphs showing emission factors for buses and trucks.](image)
Population of Construction Machinery
Growing Rapidly in China

2000-2013年工程机械保有量（见下图）
Population trends of construction machinery in 2000~2013
Domestic shipping along busy inland waterway and the coast are also major pollution sources

China has the world’s largest inland waterway network, both in terms of length and freight volume.

Coastal cities in China:
Home to world’s largest ports and affected by high levels of pollution

Mean PM$_{2.5}$ concentrations
(Dust and sea salt components of PM$_{2.5}$ removed)

World ranking of ports in terms of container throughput presented in parenthesis.
Vessels Are Large Contributors To PM$_{2.5}$ in Shanghai

- **Regional influence**: 16%~36%
- **Local Sources**: 64%~84%
- **Mobile Sources**: 29.2%
- **Coal Burning**: 13.5%
- **Industry**: 28.9%
- **Dust**: 13.4%
- **Ship**: 5%~8%
- **Others**: 15.0%
深圳市船舶的排放分担率

**Contribution Rate Of Vessels In Shenzhen**

- **PM10**
  - 总排放量为59,359吨
  - 船舶贡献率为2.90%

- **PM2.5**
  - 总排放量为27,116吨
  - 船舶贡献率为5.20%

- **NOx**
  - 总排放量为121,982吨
  - 船舶贡献率为16.40%

- **SO2**
  - 总排放量为22,252吨
  - 船舶贡献率为58.90%

- **CO**
  - 总排放量为230,697吨
  - 船舶贡献率为1.00%

- **VOC**
  - 总排放量为130,801吨
  - 船舶贡献率为0.50%
Non-road engine emissions are very significant
India Is Also Facing an Air Pollution Crisis But With A Very Different Traffic Mix Than China

2 and 3 Wheeled Vehicles Dominate! Also Large Diesel Car Population
In Ho Chi Minh City the rate of household using motorbikes just meets 9%. Two-wheel vehicles take 87% of transportation flow in Hanoi City.

**Picture 1.** Transportation on Dan Chu six-way cross road, Ho Chi Minh City

**Picture 2.** Transportation on Lang Ha street, Hanoi
Vietnam Has A Large Bicycle Population as Well
PM10 Exposures in Hanoi

Commutes Exposure to Particulate Matter and Carbon Monoxide in Hanoi, Vietnam: A Pilot Study
East West Center Working Paper No. 64, Nov 2006
Conclusions

• Technology Exists Today Which Can Dramatically Reduce Exposure to Vehicle Related Air Pollution and Its Use is Spreading

• But Diesel NOx in the Real World Remains a Big Challenge Resulting in High NO₂ Levels

• Traffic Mix Varies Widely Across the World
  – US – Small Diesel Car Population
  – Europe – Almost 50% Diesel Cars
  – China – Few Diesel Cars but Large Non Road & Marine Sectors
  – India – Almost 50% Diesel Cars; Large 2-3 Wheel Population
  – Vietnam – Dominated by Motorcycles & Scooters with High Direct PM₁₀ Exposures
Conclusions (2)

- US - Exposures to CO, HC, NOx & PM From Vehicles Coming Down But Still O₃ and PM Problems
- EU – Similar Except Roadside NO₂ Remains Serious
- China – PM₂.₅ Exposures Improving Slowly But O₃ Worsening in Some Areas
- India – Very Serious PM₂.₅ From Multiple Sources
- Vietnam – On Road & Roadside PM Exposures Very High