Euro 6/VI and beyond: Next steps in global and Indian markets

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Global Developments on Emission Standards
Vehicle emission standards are tightening further

- US implementation of Tier III light-duty emission standards began from MY 2017 onwards
- US Truck emissions standards revision will happen in 2020 led again by California
- Euro 6/VI fully phased in
  - All four packages of Real-driving emissions (RDE) adopted
  - Euro VI E implemented: Inclusion of PN measurement for HDV off-cycles emissions; cold start in ISC;
  - Transition to WLTP ongoing, NEDC will be phased out
- Japan, Korea, China have also adopted World Harmonized Light-duty Vehicles Testing Procedure (WLTP)
- China 6/VI emission standards surpass Euro 6/VI emission standards
- Euro 7 proposal expected in 2020; China VII discussions to begin later this year
Comparison between China 6 (a and b), Euro 6, Tier 2 and LEV 3 standards

1. Emissions limits are those for Type I test (regular temperature, cold start emission test)
2. For diesel light-duty vehicles, Europe and China regulate HC and NOx, instead of NMOG+NOx
3. For gasoline light-duty vehicles, Europe and China regulate NMHC and NOx, instead of NMOG+NOx
4. This analysis simply compares direct emission limits, and does not take into consideration the differences in test cycle and procedures among various regulatory programs
China 6 emission standards are an ambitious step forward

- Emission limits are fuel neutral and more stringent than those in Euro 6
- $\text{N}_2\text{O}$ emission limits
- Stringent evap. limits, innovative 48-hr test procedure, OBD and ORVR requirement
- OBD provisions largely based on CA OBD II with a few modification
- Modified RDE boundary conditions
## Comparison of China V, China VI and Euro VI

<table>
<thead>
<tr>
<th>Engine test cycle</th>
<th>China V/Euro V</th>
<th>Euro VI</th>
<th>China VI-a</th>
<th>China VI-b</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO\textsubscript{x} (g/kWh)</td>
<td>2</td>
<td>0.46</td>
<td></td>
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<tr>
<td>PM (g/kWh)</td>
<td>0.03</td>
<td>0.01</td>
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<td></td>
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<tr>
<td>PN (#/kWh)</td>
<td>No limit</td>
<td>6E+11</td>
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</table>

<table>
<thead>
<tr>
<th>PEMS test</th>
<th>No</th>
<th>Yes</th>
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<tr>
<th>Emission limits on transient cycle</th>
<th>NO\textsubscript{x} (g/kWh)</th>
<th>PEMS test</th>
<th>NO\textsubscript{x} (g/kWh)</th>
<th>PEMS test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.69 (CF=1.5)</td>
<td>No</td>
<td>1.2E+12 (CF=2.0)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>PN (#/kWh)</th>
<th>No limit</th>
<th>No limit</th>
<th>&lt;2,400 m</th>
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</table>

<table>
<thead>
<tr>
<th>Altitude boundary for PEMS test</th>
<th>&lt;1,700 m</th>
<th>&lt;1,700 m</th>
<th>&lt;2,400 m</th>
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</thead>
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<tr>
<th>Pay load for PEMS test</th>
<th>50%-100% (Euro VI-c and before)</th>
<th>50%-100% (Euro VI-d)</th>
<th>10%-100%</th>
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</thead>
</table>

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<tr>
<th>OBD requirements</th>
<th>Euro V OBD</th>
<th>Euro VI OBD</th>
<th>Euro VI OBD + US anti-tampering provisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote OBD data reporting</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
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</tbody>
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<tr>
<th>Emission durability periods for different vehicle categories</th>
<th>China V/Euro V</th>
<th>Euro VI</th>
<th>China VI-a</th>
<th>China VI-b</th>
</tr>
</thead>
<tbody>
<tr>
<td>100,000 km/5 years</td>
<td></td>
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<tr>
<td>200,000 km/6 years</td>
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<tr>
<td>500,000 km/7 years</td>
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<tr>
<td>160,000 km/5 years</td>
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<td>300,000 km/6 years</td>
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<th>Emission warranty program</th>
<th>No</th>
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Euro 7/VII agenda

- **Fuel neutral:** e.g. same limits for gasoline and diesel vehicles; Low temperature test for diesels
- **Technology neutral:** e.g. no exclusions from PN limit for port fuel injected gasoline or CNG
- **Cycle neutral:** e.g. same limits for WHTC/WHSC; better coverage of urban driving under RDE
- **Stringent:** e.g. Tighter than China 6b, how close to US 2025?
- **More comprehensive coverage of pollutants:** e.g. PN below 23 nm; CO in RDE; limits for NH₃, CH₄, N₂O
- **Durable:** e.g. emissions warranty, durability and ISC to cover full vehicle life; anti-tempering provisions
- **Improved monitoring:** e.g. on-board NOx tracking & logging requirements
BS VI Regulation and Implementation
BS VI ≠ Final Euro 6/VI even after 2023

- WLTP not adopted
- On-board fuel consumption meters not included
- Real-driving emissions (RDE) proposal not consistent with Euro 6d
  - Not clear if PN will be monitored only or confirmed
  - Conformity factors not decided
  - Cold start does not appear to be included
  - Use of reference fuel, not market fuel
  - No public dissemination of RDE data
  - No in-service conformity using RDE
- Euro VI D, and E provisions (Increased share of urban driving, cold start and PN testing during in-service conformity) not included
- Relaxed emission limits for 3-wheeler NOx
Ongoing concerns about implementation of Bharat VI standards

- Consistent fuel quality across the country
- Adequate validation of aftertreatment systems
- Overall increased cost of vehicles
- On-board usage and maintenance of aftertreatment systems.
- Nationwide distribution infrastructure & Standard grade Urea availability.
- Tampering with aftertreatment systems and on-board diagnostics
- Driver/Cleaner/Owner Awareness
- **Effectiveness of compliance and enforcement programs**
2023 and beyond agenda for vehicle emission standards in India

- WLTP should be adopted from April 2023. Compliance with RDE should be based on WLTP correlation.
- Emphasis on in-use conformity and transparency needed.
- Refueling evaporative emissions control needed.
- Update CMVR to include use of remote sensing and OBD for in-use emissions monitoring.
- Replace traditional PUC program with a combination of remote sensing, on-board emissions monitoring, and limited scale loaded tests at I&C stations.
- BS VII discussions should begin now with a goal of implementation by April 2025 – National Auto Policy proposal gives a good starting point.
- Target 2028 as a date for no diesel without filter through scrappage of pre-BSIV and DPF retrofits on remaining BS-IV.
http://www.theicct.org/
@theicct
anup@theicct.org
Emission testing of a new BSIV 3.5L bus engine

![Graph showing emission testing results for a new BSIV 3.5L bus engine. The graph plots PM (grams/kWh) vs. NOx (grams/kWh) with different test conditions and limits.]
Remote sensing capable of evaluating both fleet and model level emissions

$\text{CO}_2, \text{CO}, \text{NO}, \text{NO}_2, \text{HC, NH}_3, \text{SO}_2, \text{PM}$
Diesel car sales have started to implode in major EU member states

http://www.theicct.org/blogs/staff/cities-driving-diesel-out-european-car-market
The mission of ICCT is to dramatically improve the environmental performance and efficiency of cars, trucks, buses and transportation systems in order to protect and improve public health, the environment, and quality of life.

- Non-profit research organization
- Air Pollution and Climate Impacts
- Focus on regulatory policies and fiscal incentives
- Activity across modes including aviation and marine
- Global outreach, with special focus on largest markets
Government testing has confirmed earlier findings and points to numerous other defeat devices.
US LDV Tier 3 – Vehicle and Fuel Standards

- Vehicle standards highlights
  - Starts with MY2017 and fully phased-in by 2025.
  - Compared with to Tier 2
    - 80% reduction in fleet average NOx+NMOG (160 mg/mile to 30 mg/mile)
    - 70% reduction in per vehicle PM (10 mg/mile to 3 mg/mile)
    - Eventual harmonization of PC and LDT standards by 2025
  - 150,000 mile durability by 2020
  - 120,000 mile durability option for smaller classes, but 15% tighter standard
  - Evaporative emissions tightening

- Fuels standards highlights
  - Sulfur content S < 10 ppm annual average, 80 ppm cap
  - E10 cert fuel

http://www.epa.gov/otaq/tier3.htm
Major reform of China Clean Air Law strengthens authority for compliance and enforcement

- Clear authority to enforce standards
  - Recall authority is established for motor vehicles and off-road engines
  - Clear authority of central and provincial environmental agencies (MEP and provincial EPBs) to impose large fines (1-3 times product value) for producing, selling and importing non-compliant vehicles
  - Clear authority of the industry ministry (MIIT) to suspend or discontinue the production of violating vehicles/engines

- Clear authority of environmental agencies to perform compliance testing
  - Authority of MEP and provincial EPBs to investigate and test newly produced and sold vehicles and engines
  - Authority of local EPBs to perform random onsite and roadside emission inspection and testing, including remote sensing tests.

- Highlighted shared burden among government, industry, and consumers
  - Manufacturers of vehicles and engines shall test their products to ensure emission compliance before introducing the products into commerce
  - Manufacturers shall publish their emission compliance test result information to the public
  - Manufacturers shall recall their vehicle/engine products if they are found not in compliance with standards due to design, manufacturing defects
  - Consumers are prohibited from tampering/modifying emission control devises (incl. OBDs)
A combination of regulatory tools and incentives is necessary to reduce transport emissions

**New Vehicle Policies**
- Stringent tailpipe emission standards
  - BS VI for on-road vehicles
  - Stage V for non-road vehicles
- Stringent evaporative emission standards
- Strong compliance and enforcement program
- Promotion of electric drive

**Clean Fuel Policies**
- Ultra-low sulfur fuels
- Stage I and II evaporative controls

**In-use vehicle emission control**
- On-board diagnostics (OBD) based inspection and maintenance program
- Remote sensing or other in-use emissions testing program
- Scrappage of old (especially diesel) vehicles
- Diesel particulate filter (DPF) retrofits for BS III vehicles

**Demand management**
- Restrictions on use of older/more polluting vehicles
- Additional fees for older/more polluting vehicles
- Low Emission zones (LEZ)