Emission Factors for Indian In Use Vehicles

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Automotive Research Association of India (ARAI), Pune, India

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Denpasar, Bali, Indonesia
25th November 2013

Presentation by
Amita Baikerikar
# ARAI Overview

<table>
<thead>
<tr>
<th>Establishment</th>
<th>: 1966</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Pune, INDIA (150 km from Mumbai)</td>
</tr>
<tr>
<td>Manpower</td>
<td>500+</td>
</tr>
<tr>
<td>Accreditations</td>
<td>ISO 9001, 14001, OHSAS 18001 &amp; NABL</td>
</tr>
</tbody>
</table>
ARAI’s Activities

R&D: Automotive Industry Projects, National Interest Projects and Internal R&D Projects

Certification Testing / Homologation

Assisting GoI in Formulation of Regulatory Standards and Harmonization of Regulations

Education and Training

Consulting Services
Presentation Layout

- Mobility - Indian Scenario
- Air Quality and Transportation
- Project – Source Apportionment
- Emission Factor development for Indian Vehicles
- Way Forward
Indian Scenario – Mobility

- 125 million registered vehicles in India
- Automobile production to double by 2020-21

- Vehicle density per 1000 population in India expected to grow to 65 by 2030

Source: SIAM and ACMA Presentations

Source: BP Energy Outlook 2030, Jan 2012
Indian Scenario – Mobility

Adapted from SIAM Presentation 2012 on Emissions & Fuel Efficiency
### Air Quality Trend for NO₂

**Concentration (µg/m³)**

- 2007: 33
- 2008: 31
- 2009: 29
- 2010: 28
- 2011: 29

**Year**

- 2007
- 2008
- 2009
- 2010
- 2011

**NAAQS Limits for NO₂**

- 180 µg/m³

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**Source:** CPCB ENVIS Air Data

### Status of Ambient Air Quality in Metropolitan Cities of India

### Air Quality Trend for PM₁₀

**Concentration (µg/m³)**

- 2007: 110
- 2008: 117
- 2009: 131
- 2010: 131
- 2011: 131

**Year**

- 2007
- 2008
- 2009
- 2010
- 2011

**NAAQS Limits for PM₁₀**

- ≤ 60 µg/m³

---

**Source:** CPCB ENVIS Air Data
Source: CPCB
Air Quality & kerbside monitoring

- Criteria Pollutants: SPM, RSPM, PM10, PM2.5, SO2, NO2, CO, O3
- Specific Pollutants: NMHC, THC, Benzene, Alkene, 1-3 Butadiene, Aldehydes, PAH

Emission Inventory

- Point Sources: Major Industries
- Area Sources: Domestic & other sources/activities
- Line Sources: Emission factor determination of Indian in use vehicles

Source Apportionment

- Receptor Modeling: Detailed chemical analysis of PM, CMB (Source Profiling of vehicular emissions)

Database on criteria & specific pollutants

Quantification of emission loads from point, area & line sources within the receptors impact zone

Percentage contribution to air quality by different types of sources

Projections on Air Quality Improvement under different emission scenarios/management options through modeling
Objectives of the project:

“To develop “Emission Factors” for different category of vehicles to reflect the variance in fuel quality, vehicle technology & age, maintenance practices, tailpipe treatment, etc. by conducting exhaust mass emission tests”.
**Scope of the project**

1. Determination of EF for each representative vehicle model considering vehicle technology, age- 89 Vehicles/450 tests
   - 2 Wheelers, 3 Wheelers, Passenger Cars, LCVs and HCVs

2. Exhaust gas chemical speciation for non regulated pollutants:
   - Benzene, 1-3, Butadiene, PAH and Aldehydes

3. Tests with commercial fuel- Before and after maintenance & Tests with different fuel specifications
Project Execution Methodology

• Vehicle sourcing
  – Individuals, Organizers, transport operators ARAI employees, public acquaintances & Rickshaw unions
  – TA/CoP test vehicles

• Vehicle Testing
  – Prevalent Certification test procedures
  – Prevalent test cycles
  – Inertia setting

• 62 no. EF based on
  – vehicle categorization
  – Engine capacity
  – Fuel
Indian Driving Cycle for 2 and 3 wheelers

Procedure: Cold Start + 40 s idling + 4 Warm-up + 6 sampling cycles

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Time in s</th>
<th>Dist in m</th>
<th>Avg. Speed in km/h</th>
<th>Max. Acceleration m/s²</th>
<th>Maximum Deceleration m/s²</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDC (6 cycles)</td>
<td>648</td>
<td>3948</td>
<td>21.93</td>
<td>0.65</td>
<td>-0.63</td>
</tr>
</tbody>
</table>
2W Emission Control Regulation History in India

(All figures in g/km)

<table>
<thead>
<tr>
<th></th>
<th>CO (g/km)</th>
<th>HC (g/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991 Norms</td>
<td>12 to 30</td>
<td>8 to 12</td>
</tr>
</tbody>
</table>

**Reduction**

- **1996**: 92%
- **BS - I (2000)**: 88%
- **BS - II (2005)**: 72%
- **BS - III (2010)**: 78%

**2W Emission Factors**

- **2-Stroked Engine**
  - **1991-96**: 7.68
  - **1996-2000**: 4.06
  - **Post 2000**: 1.95
  - **Post 2005**: 0.31
  - Reduction: 96%

- **HC + NOx**
  - **1991-96**: 4.78
  - **1996-2000**: 2.58
  - **Post 2000**: 2.42
  - **Post 2005**: 0.75
  - Reduction: 85%

*ARAII: Progress through Research*
2W Emission Control Regulation History in India

(All figures in g/km)

<table>
<thead>
<tr>
<th></th>
<th>CO (g/km)</th>
<th>HC (g/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991 Norms</td>
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<td>8 to 12</td>
</tr>
<tr>
<td>Reduction</td>
<td>92 %</td>
<td>88 %</td>
</tr>
</tbody>
</table>

**2W Emission Factors**

4 - Stroke
3W – Gasoline Emission Control Regulation History in India

(All figures in g/km)

<table>
<thead>
<tr>
<th>1991 Norms</th>
<th>CO (g/km)</th>
<th>HC (g/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12 to 30</td>
<td>8 to 12</td>
</tr>
</tbody>
</table>

Reduction

- CO: 90%
- HC: 84%

### 3W – Gasoline Emission Factors

<table>
<thead>
<tr>
<th>Year</th>
<th>CO</th>
<th>HC + NOx</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>6.75</td>
<td>5.4</td>
</tr>
<tr>
<td>BS - I (2000)</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>BS - II (2005)</td>
<td>2.25</td>
<td>2</td>
</tr>
<tr>
<td>BS - III (2010)</td>
<td>1.25</td>
<td>1.25</td>
</tr>
</tbody>
</table>

### Comparison

- CO: 1996: 6.75 g/km, BS- I: 4 g/km, BS- II: 2.25 g/km, BS- III: 1.25 g/km
- HC + NOx: 1996: 5.4 g/km, BS- I: 2 g/km, BS- II: 2 g/km, BS- III: 1.25 g/km

- CO Reduction: 81%
- HC + NOx Reduction: 77%

NA: Limited data
**3W – Diesel Emission Control Regulation History in India**

(All figures in g/km)

<table>
<thead>
<tr>
<th></th>
<th>CO (g/km)</th>
<th>HC (g/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992 Norms</td>
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<td>8 to 12</td>
</tr>
<tr>
<td>Reduction</td>
<td>90%</td>
<td>84%</td>
</tr>
</tbody>
</table>

**3W – Diesel Emission Factors**

- **CO**
  - 1996: 2.72 g/km
  - BS - I (2000): 1.0 g/km
  - BS - II (2005): 0.97 g/km
  - BS - III (2010): 0.5 g/km
  - Reduction: -93%

- **HC + NOx**
  - 1996: 5.4 g/km
  - BS - I (2000): 0.85 g/km
  - BS - II (2005): 0.85 g/km
  - BS - III (2010): 0.14 g/km
  - Reduction: -91%

- **PM**
  - 1996: 0.14 g/km
  - BS - I (2000): 0.1 g/km
  - BS - II (2005): 0.05 g/km
  - Reduction: -64%

- **CO**
  - Only one vehicle data
  - 1991: NA
  - 1996-2000: 9.16 g/km
  - Post 2005: 2.09 g/km
  - Reduction: -96%

- **HC + NOx**
  - Only one vehicle data
  - 1991: NA
  - 1996-2000: 1.56 g/km
  - Post 2005: 0.85 g/km
  - Reduction: -58%

- **PM**
  - Only one vehicle data
  - 1991: NA
  - Post 2005: 0.78 g/km
  - Reduciton: NA
Indian Driving Cycle for 4 Wheelers

- Part 1: 780 sec
- Part 2: 400 s
- One Cycle of 195 sec
- Max Speed 90 kph
### Passenger Cars & Light Commercial Vehicles - Gasoline Emission Control Regulation History in India

(All figures in g/km)

<table>
<thead>
<tr>
<th>Norms</th>
<th>CO (g/km)</th>
<th>HC (g/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>14.3 to 27.1</td>
<td>2.0 to 2.9</td>
</tr>
<tr>
<td>Reduction</td>
<td>93 %</td>
<td>91 %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Norms</th>
<th>CO (g/km)</th>
<th>HC (g/km)</th>
<th>NOx (g/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS – III</td>
<td>2.30</td>
<td>0.20</td>
<td>0.15</td>
</tr>
<tr>
<td>BS – IV</td>
<td>1.00</td>
<td>0.10</td>
<td>0.08</td>
</tr>
</tbody>
</table>

#### Passenger Cars - Gasoline Emission Factors

<table>
<thead>
<tr>
<th>Year</th>
<th>CO (g/km)</th>
<th>HC (g/km)</th>
<th>NOx (g/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991-96</td>
<td>8.68</td>
<td>2.72</td>
<td>-88%</td>
</tr>
<tr>
<td>1996</td>
<td>4.53</td>
<td>2.2</td>
<td>-82%</td>
</tr>
<tr>
<td>BS - I (2000)</td>
<td>4.75</td>
<td>2.35</td>
<td>-88%</td>
</tr>
<tr>
<td>BS - II (2001)</td>
<td>1.79</td>
<td>1.41</td>
<td>-88%</td>
</tr>
<tr>
<td>BS - III (2005)</td>
<td>1.00</td>
<td>0.38</td>
<td>-88%</td>
</tr>
<tr>
<td>BS - IV (2010)</td>
<td>0.21</td>
<td>0.18</td>
<td>-88%</td>
</tr>
</tbody>
</table>

[Image of bar charts showing emission reductions]
Passenger Cars & Light Commercial Vehicles - Diesel Emission Control Regulation History in India

(All figures in $g/km$)

<table>
<thead>
<tr>
<th></th>
<th>CO ($g/km$)</th>
<th>HC + NOx ($g/km$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992 Norms</td>
<td>14.3 to 27.1</td>
<td>4.7 to 6.9</td>
</tr>
<tr>
<td>Reduction</td>
<td>96%</td>
<td>94%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Norms</th>
<th>CO ($g/km$)</th>
<th>NOx ($g/km$)</th>
<th>HC + NOx ($g/km$)</th>
<th>PM ($g/km$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS – III</td>
<td>0.64</td>
<td>0.50</td>
<td>0.56</td>
<td>0.05</td>
</tr>
<tr>
<td>BS – IV</td>
<td>0.50</td>
<td>0.25</td>
<td>0.30</td>
<td>0.025</td>
</tr>
</tbody>
</table>

Passenger Cars – Diesel Emission Factors
Overall Bus Driving Cycle for LCV and HCV

Overall Bus Driving Cycle

Procedure: Cold Start + 4 Warm-up + 6 sampling cycles (5.1 km)
HCV Emission Control Regulation
History in India

(All figures in g/kWh)

HCV Emission Factors
(All figures in g/km)

CO
- 16.18
- 4.48
- 4.99
- 3.92
-76%
-92%

HC
- 2.52
- 1.46
- 0.32
- 0.16

PM
- 1.99
- 1.21
- 1.16
- 0.3

NOx
- 12.54
- 8.04
- 6.53
-48%

PM
- 3.5
- 3.5
- 0.2

(Arrow indicates percentage reduction compared to initial values.)
Emission Factors for Non Regulated Pollutants

- Benzene and 1,3 butadiene
- Polycyclic Aromatic Hydrocarbons + Aldehydes and Ketones
- High Resolution Gas Chromatograph (HRGC)
- High Performance Liquid Chromatograph (HPLC)
Non-regulated Pollutant Emission Factors

Benzene emission from different vehicle categories

1-3 Butadiene emission from different vehicle categories

Total Aldehyde emission from different vehicle categories

Total PAH emission from different vehicle categories

ARAIR®
Progress through Research
Way Forward…

• The sample size is limited and there is a need to test more number of vehicles.
  – More emission factors for BSIII technology and BS IV technology vehicles of four wheelers need to be developed
  – BSIII technology of two/three wheeled vehicles need to be developed.

• Vehicular emission factors need to be evolved on a continuous basis for regulated, non-regulated and greenhouse gases.

• Vehicular Non-exhaust emission profiles generation for in use vehicles need to be undertaken.
  – Brake Pad
  – Tyre Wear
Way Forward…

- Establish EF on city specific Driving Cycles
  - Continuous change in the road traffic pattern.

- Use of PEMS to evolve real world emission data from various vehicle categories across selected cities in the country.

- Since activity of data collection for mobile source is resource intensive, tool for advanced methodology for simpler and quicker approach needs to be worked out ???
Thank You
Air Quality Management Project

The project consists of three major sub-components as below:

1. Development of emission factors for Indian vehicles

2. Vehicle source profiling

3. Ambient air quality monitoring, Emission Inventory and Source Apportionment
On-Board Emission Measurement System

- Typical applications
- Compliance of in use vehicles for prevalent emission norms
- Monitoring of exhaust emissions from in use vehicles
- On road performance evaluation of vehicles; evaluation of exhaust emissions w.r.t. to other engine / vehicle parameters viz.; gear position, throttle, acceleration, clutch, brake, etc.
- On vehicle / on road engine / ECU calibration
Salient Features

- The facility will be based on the test set up recommended by GRPE- PMP group, which includes mainly, dilution tunnel with PCF (Pre-classifier) to cut down exhaust particles below 2.5 µm and HEPA (High Efficiency Particulate Filter) to provide dilution air with filtering efficiency 99.99%, VPR (Volatile Particle remover) and CPC (Condensation Particle Counter)

- In addition to this certification setup, it includes Engine Exhaust Particle Sizer (EEPS) for online nano particle measurement for its number, surface area and size distribution pattern which will be useful for research and development

- Solid Particle Measurement from 23 nm to 2.5 µm as per EURO V/EURO VI

- Nano Particle size range between 5.6 nm to 560 nm on Transient Cycle for On-Line Measurement

- Unique Facility at National level for measuring particle number, size, surface & volume

- Useful for Export Homologation as per Euro V /VI and for R&D
Nano Particle Measurement Equipment Setup

- HEPA filter
- Gasoline DT
- Diesel DT
- LFE
- Gasoline Exhaust IN
- Diesel Exhaust IN
- Nano PM Equipment
- GRPE PSS
- PSS System
- CVS
Nano Particle Measurement Setup

**Volatile Particle Remover (VPR)**
Model: MD19-2E (PND1)
ASET 15-1 (ET + PND2)
Evaporation Tube temperature: Max 400 °C
Primary Dilution air: 1.5 lpm  D.R.1 = 1 to 15
Secondary Dilution air: 0 – 15 lpm  D.R.2 = 1 to 3000
Approx. Heating Time: 2 min for 200 °C, 4 min for 300°C,

**Condensation Particle Counter (CPC)**
Model 3790
Concentration range: 0 to 1 x $10^4$ (particles/cm³)
Max. Detectable Particle Size: >3 μm
Aerosol flow rate: 1 lpm ± 0.05 lpm

**Engine Exhaust Particle Sizer (EEPS)**
Model: 3090
5.6 to 560 nm
Aerosol Inlet: 10 L/min
Sheath Air: 40 L/min
Particle Size Resolution: 16 channels per decade (total 32)
### New Emission Test Facilities under NATRip

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transient Engine Dynamometers with Full Flow Dilution Tunnel</td>
<td>(220 kW &amp; 500 kW)</td>
</tr>
<tr>
<td>4 X 4 Chassis Dynamometers for Emissions</td>
<td></td>
</tr>
<tr>
<td>Climatic 4 X 4 Chassis Dynamometer with Solar Simulation</td>
<td></td>
</tr>
<tr>
<td>4 X 4 Chassis Dynamometers for Mileage Accumulation</td>
<td></td>
</tr>
<tr>
<td>SHED for Gasoline Evaporative Emissions</td>
<td></td>
</tr>
</tbody>
</table>

### 4 X 4 Chassis Dynamometer for Emission:  
- All chassis dyno Facilities will be ready In 12-18 months  
- Conforming to Euro V  
- 2 Axle with 150 kW 2 Nos. AC motor

**Climatic chamber 4 X 4 Chassis Dynamometer with Solar simulation:**

- Climatic Chamber Conditions: -30°C to +55°C

### 4 X 4 Chassis Dynamometer with Robot for Mileage Accumulation:
Transient Engine Dynamometers with Full Flow Dilution Tunnel (220 kW & 500 kW)

- **Broad Specifications:**
  - **Heavy Duty Transient Dynamometer:** 500kW @ 1600 to 3200 rpm, 3000 Nm @ 800 to 1600 rpm.
  - **Heavy Duty Transient Dynamometer:** 220kW @ 2200 to 4500 rpm, 960 Nm @ 1000 to 2200 rpm.
  - **Emission Analyser:** Suitable for measurement up to Euro V.

**Useful for:**
- Automotive BSIV, BSIII
- Tractor Trem IIIA
- CEV BSIII
- Export Homologation
- High Altitude Simulation
- Friction Mapping testing
- Vehicle Simulation
Full Flow Emission Measurement facility for Transient Engine Dynamometers

- **Emission & Particulate Measurement Details**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO (L) NDIR Analyser Range</td>
<td>50 to 5000 ppm</td>
</tr>
<tr>
<td>THC HFID Analyser Range</td>
<td>10 to 5000 ppmC</td>
</tr>
<tr>
<td>CH4/ THC HFID Analyser Range</td>
<td>10 to 5000 ppmC</td>
</tr>
<tr>
<td>NO/ NOx HCLD Analyser Range</td>
<td>10 to 5000 ppm</td>
</tr>
<tr>
<td>CO2 NDIR Analyser Range</td>
<td>0.5 to 6 % Vol</td>
</tr>
<tr>
<td>NH3 HCLD Analyser Range</td>
<td>10 to 1000 ppm</td>
</tr>
<tr>
<td>Model</td>
<td>Full Flow Particulate Measurement</td>
</tr>
<tr>
<td>Make</td>
<td>HORIBA, Japan</td>
</tr>
<tr>
<td>Full flow dilution tunnel diameter</td>
<td>φ 18”</td>
</tr>
<tr>
<td>Secondary dilution tunnel diameter</td>
<td>φ 5”</td>
</tr>
<tr>
<td>Filter Holder Size</td>
<td>φ47mm &amp; φ70mm</td>
</tr>
<tr>
<td>Suitability</td>
<td>BSIII &amp; BSIV ESC as well as Transient testing</td>
</tr>
</tbody>
</table>

New Emission Test Facilities under NATRiP
## National Ambient Air Quality Standard (CPCB) (16th Nov. 09)

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Pollutants</th>
<th>Time Weighted Average</th>
<th>Concentration in Ambient Air</th>
<th>Method of measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Industrial, Residential, Rural and Other Area</td>
<td>Industrial Areas</td>
</tr>
<tr>
<td>1</td>
<td>Sulphur Dioxide (SO₂), µg/m³</td>
<td>Annual</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 hours</td>
<td>80</td>
<td>120</td>
</tr>
<tr>
<td>2</td>
<td>Nitrogen Dioxide (NO₂), µg/m³</td>
<td>Annual</td>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 hours</td>
<td>80</td>
<td>120</td>
</tr>
<tr>
<td>3</td>
<td>Particulate Matter (size less than 10 µm) or PM 10 µg/m³</td>
<td>Annual</td>
<td>60</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 hours</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>4</td>
<td>Particulate Matter (size less than 2.5 µm) or PM2.5</td>
<td>Annual</td>
<td>40</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 hours</td>
<td>60</td>
<td>NA</td>
</tr>
<tr>
<td>5</td>
<td>Ozone (O₃), µg/m³</td>
<td>8 hours</td>
<td>100</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 hour</td>
<td>180</td>
<td>NA</td>
</tr>
<tr>
<td>6</td>
<td>Lead (Pb), µg/m³</td>
<td>Annual</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 hours</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>7</td>
<td>Carbon Monoxide (CO) mg/m³</td>
<td>8 hours</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 hour</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>Ammonia (NH₃), µg/m³</td>
<td>Annual</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 hours</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>9</td>
<td>Benzene (C₆H₆), µg/m³</td>
<td>Annual</td>
<td>5</td>
<td>NA</td>
</tr>
<tr>
<td>10</td>
<td>Benzo a Pyrene (BaP) (particulate phase only), ng/m³</td>
<td>Annual</td>
<td>1</td>
<td>NA</td>
</tr>
<tr>
<td>11</td>
<td>Arsenic, ng/m³</td>
<td>Annual</td>
<td>6</td>
<td>NA</td>
</tr>
<tr>
<td>12</td>
<td>Nickel, ng/m³</td>
<td>Annual</td>
<td>20</td>
<td>NA</td>
</tr>
</tbody>
</table>

**Note:**
- New NAAQ Standards
- Old NAAQ Standards
Inertia setting for different categories of vehicles

For the purpose of mass emission testing and constant speed emission testing, the following inertia setting for the dynamometer was used.

<table>
<thead>
<tr>
<th>Veh. Cat</th>
<th>Inertia Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 wheeler</td>
<td>ULW +75 kg</td>
</tr>
<tr>
<td>3-wheelers gasoline</td>
<td>225 kg (3 passengers X 75)</td>
</tr>
<tr>
<td>3-wheeler diesel</td>
<td>GVW</td>
</tr>
<tr>
<td>Passenger cars</td>
<td>ULW+225 kg (3 passengers X 75 kg)</td>
</tr>
<tr>
<td>Multi Utility Vehicles</td>
<td>ULW+450 kg (6 passengers X 75kg)</td>
</tr>
<tr>
<td>LCV: Bus</td>
<td>ULW + 1500 kg (equivalent to 20 passengers of 75 kg weight each)</td>
</tr>
<tr>
<td>LCV: Trucks:</td>
<td>GVW ( As specified by the vehicle manufacturer)</td>
</tr>
<tr>
<td>HCV: Bus</td>
<td>ULW + 4500 kg (Equivalent to 60 passengers of 75 kg each)</td>
</tr>
<tr>
<td>HCV: Trucks</td>
<td>GVW (To be limited to 20 ton max. for GVW &gt; 20tons. If GVW is less than 20 tons, Inertia set to the maximum specified GVW)</td>
</tr>
</tbody>
</table>
# Emission Factors for Indian Vehicles

## 1. Methodology:
The vehicle categorization is given in the table below:

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Gasoline</th>
<th>Diesel</th>
<th>CNG</th>
<th>LPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles type</td>
<td>Two Stroke</td>
<td>Four Stroke</td>
<td>Two Stroke</td>
<td>Four Stroke</td>
</tr>
<tr>
<td>Two wheeler</td>
<td>Less than 80CC; and above 80CC</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Less than 100CC; and above 200CC</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Above 200CC</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Three wheeler</td>
<td>Less than 200CC</td>
<td>Less than 200CC</td>
<td>-</td>
<td>Upto 500CC; and Above 500CC</td>
</tr>
<tr>
<td>Four wheeler (Car + multi-utility vehicles)</td>
<td>Less than 1000CC; 1000 – 1400CC; and Above 1400CC</td>
<td>Less than 1600CC; 1600 – 2400CC; and Above 2400CC</td>
<td>Less than 1000CC; 1000 – 1400CC; and Above 1400CC</td>
<td>Less than 1000CC; 1000 – 1400CC and Above 1400CC</td>
</tr>
<tr>
<td>LCV</td>
<td>-</td>
<td>Less than 3000CC; and Above 3000CC</td>
<td>Less than 3000CC; and Above 3000CC</td>
<td>Less than 3000CC; and Above 3000CC</td>
</tr>
<tr>
<td>HCV</td>
<td>-</td>
<td>Above 6000CC</td>
<td>Above 6000CC</td>
<td>-</td>
</tr>
</tbody>
</table>