Motor Vehicle Inspection and Maintenance: The Worldwide Experience

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Summary

• Air Pollution Causes Serious Health and Environmental Problems
• A Comprehensive Strategy is Needed
• I/M Plays A Critical Role
• The Keys To Successful I/M
• Conclusions

The Global Health Impact of Urban Air Pollution

Annual Premature Deaths
Total: 799,000

Source: WHO

The World Health Report 2002

Benzene Concentration in Ambient Air of Delhi

Residential Area Industrial Area Traffic Intersection

Source: S. B. et al.
Annual average concentration of Benzo(a) Pyrene Levels in RSPM in the Ambient air of Delhi (Source: NEERI, Nagpur)

Air quality Trends of RSPM / PM$_{10}$ in Major Cities

Concentration of PM$_{2.5}$, PM$_{10}$, and TSPM in Delhi (Traffic Intersections Give The Highest Readings)

Lung Function Impairment in Residents of Delhi (Non-smokers)
ELEMENTS OF A COMPREHENSIVE VEHICLE POLLUTION CONTROL STRATEGY

NEW VEHICLE STANDARDS IN INDIA

- Entire Country
  - Euro 2 – April 2005
  - Euro 3 – April 2010

- Major Cities
  - Delhi, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad & Ahmedabad, Pune Surat, Kanpur & Agra: Already Euro 2
  - Tighter emission norms for all private vehicles, city public service vehicles and city commercial vehicles
    - Euro 3 From April 2005
    - Euro 4 From April 2010

CURRENT 2005

<table>
<thead>
<tr>
<th>Year</th>
<th>National Metals</th>
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<tbody>
<tr>
<td>2001</td>
<td>0</td>
</tr>
<tr>
<td>2002</td>
<td>500</td>
</tr>
<tr>
<td>2003</td>
<td>1000</td>
</tr>
<tr>
<td>2004</td>
<td>1500</td>
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<td>2005</td>
<td>2000</td>
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DELHI: AIR QUALITY IMPROVEMENT PLAN (AQIP)

Chronology of Recent Actions

2001: Transport, Industry & Urban

- Replacement of all post-1990 3-wheelers and taxis with new vehicles on clean fuels
- Sulphur content in diesel reduced to 0.05% in select outlets
- Number of CNG vehicles increases: 14000 3-w; 2200 taxis; 400 buses; 250 RTVs; 9500 private (26350 total)
- Piped NG by March to 2821 domestic, 15 small and 5 large commercial establishments
- Hazardous Industry closure continues: total of 3536 closed
**Delhi: Air Quality Improvement Plan (AQIP)**

**Chronology of Actions**

**2002: Transport & Urban**
- 94 CNG stations setup up by March
- All diesel buses phased-out / converted to CNG.
- Number of CNG vehicles increases further: 35678 3-w; 4816 taxis; 2165 RTVs; 10350 private (57240 total)
- Piped NG by March to 4111 domestic, 37 small, and 5 large commercial establishments
- 16340 non-destined good vehicles turned away from entering Delhi between July and November

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**CNG Situation in Delhi**

**January 1, 2005**

- Buses 10,352
- Minibuses 4,999
- Taxis 5.69
- Three Wheelers <60,000
- Pvt. Cars 10,895
- CNG Stations 126

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**International Best Practice**

Ultra Low Sulfur Diesel Fuel Is Spreading

- **US 1993**
- **US 2006**
- **EU 2000**
- **EU 2005**
- **Japan**
- **Japan 2005-7**
- **Hong Kong**
- **South Korea**
- **Taipei, China 2007**
- **Australia**
- **Thailand**
- **India 1996**
- **India 2000**
- **India 2005**
- **India 2010**

India Continues To Lag

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**Linkage Between Fuel Sulfur and PM Emissions**

Oxidation Catalyst

PM Filter

PM Emissions

- **Other PM**
- **Sulfur**

Fuel Sulfur

- **0.01**
- **0.02**
- **0.03**
- **0.04**
- **0.05**
- **0.06**

0 500 1000 1500 2000 2500 3000 3500
One of the Weakest Aspects of the India Program Has Been the PUC I/M Program

- Test procedures and norms did not adjust to changing vehicle characteristics such as catalysts.
- PUC Center operators are not trained.
- Equipment not maintained/calibrated.
- Proper test procedure not followed.
- No well-defined criteria for authorizing/registering PUC Center.
- No auditing of PUC Center.
- Lack of centralised agency for coordination.
- The number of vehicles undergoing PUC test is very small and absence of control mechanism to identify vehicles escaping PUC.
- No analysis of the data collected.
- Existing system is prone to tampering.

Vehicle Inspection and Maintenance (I/M) Program

- **Purpose:**
  - To assure that vehicle is properly maintained and used.
  - Identify dirtiest vehicles & get them repaired.
  - Identify unsafe vehicles & get them repaired.

- **General Attributes:**
  - Relatively short.
  - Relatively simple.

- **Test Types:**
  - Idle.
  - 2-Stage Idle.
  - Steady Speed Loaded.
  - Transient Loaded.

- **Variety of Safety Tests:**

I/M Plays A Critical Role

- Improved Vehicle Maintenance
- Deterrent to Tampering
- Deterrent to Misfuelling
- Primary Enforcement Mechanism for other strategies
  - Alternative Fuel Retrofit
  - Other Retrofit.

Lessons From Mexico City I/M Program

- **Test and Repair:**
  - Very convenient for vehicle owners.
  - Very difficult to control.
  - Often degenerates into a visibly flawed program with no public support.

- **Test Only-Centralized:**
  - Good technical and administrative control.
  - Design program for profitability.
  - Legal framework to favor sanctions.
  - Minimize impact of technician on results.

Source: John Rogers
Lessons From Mexico
Gasoline Vehicle Testing Protocols

- Easy to generate False Pass on Static (Idle) Tests
- Dynamometers and NOx testing are essential to minimize False Passes
- Short, loaded-mode, constant-speed test (ASM) easy to operate at reasonable investment and cost
- Dynamic tests technically better but more difficult for low-skill technicians

Source: John Rogers

Lessons From Mexico
Harness Public Opinion

- Program success depends on public support
- Program benefits must be seen to outweigh social costs
- Must be seen to be effective, totally objective, transparent and focused on the gross polluters
- Well enforced, supervised and audited
- False Passes critically damage public opinion
- Design the Program to minimize False Passes from Day One

Source: John Rogers

Enhanced PUC system
Developed By ARAI

- Revision in Idle emission norms based on the year of vehicle manufacture
- Introduction of idle HC emission standards
- Introduction of idle CO and HC emission norms for CNG / LPG vehicles
- Will have improved test methods for gasoline and diesel vehicles
- Four gas analyzer for better accuracy
- Measurement of Engine oil temperature and engine rpm for repeatable and consistent smoke readings
- Training of PUC center operators by equipment suppliers and institutionalize the complete system
- Calibration of equipment three times per year
- Communication capability with computer for data transfer and storage

Problems with Idle CO Testing

Idle CO check:

- Proper extension pipes especially for 2&3 wheeler vehicles are not used
- Chances of leakages in the system leading to low readings
- Carburetor adjusted to pass the test
ARAI developed loaded mode test method for 2 Wheeler vehicles

- This test method was reviewed by Dr. R.A. Mashelkar in auto fuel policy report and recommended for dovetailing with the PUC system
- This system represents a significant step forward and should be emulated by other countries
- Can be extended to light duty gasoline and CNG buses

Test Methods for Checking Compliance

A. Dynamometer Smoke Test
   - Check rated rpm ± 5% manufacturer spec
   - Check road power to at least 50% of manufacturer spec
   - Smoke limit 50 HSU

B. Free Acceleration Smoke Test
   - Check rated rpm ± 5% manufacturer spec
   - Can not check road power
   - Smoke limit:
     - Pre-90: 60 HSU
     - Post 90: 50 HSU

Effectiveness of Advanced Smoke Test on Smoky Light Duty Diesel Vehicles

<table>
<thead>
<tr>
<th>Source: Matthew Tsang</th>
<th>Period</th>
<th>FAS</th>
<th>DST</th>
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### Summarising Test Attributes

<table>
<thead>
<tr>
<th>Test</th>
<th>Pollutant Measured</th>
<th>Equipment Cost (US$)</th>
<th>Building, Land Req’d</th>
<th>Effectiveness (PM)</th>
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<tbody>
<tr>
<td>Free Acceleration</td>
<td>Smoke Opacity</td>
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<tr>
<td>Lug-Down</td>
<td>Smoke Opacity</td>
<td>~70,000</td>
<td>Yes</td>
<td>70%</td>
</tr>
<tr>
<td>Lug-Down</td>
<td>PM</td>
<td>~90,000</td>
<td>Yes</td>
<td>80%</td>
</tr>
<tr>
<td>Transient DT80</td>
<td>PM</td>
<td>~100,000</td>
<td>Yes</td>
<td>90%</td>
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</tbody>
</table>

Source: Peter Anyon

### Minimising I/M Program Costs Can Be Deceptive

- Selecting a diesel I/M test presents a dilemma, as low-cost tests are initially financially attractive but may fail to detect many high polluters (and even worse may fail a large number of clean vehicles).
- On the other hand, while equipment and infrastructure capital costs can be quite high for tests that more reliably detect high polluters:
  - investment costs can be amortised over many years
  - in fact, test equipment outlays, over 5–10 years of operation are often the smallest budget item.

### Elements of A Successful I/M Program

- Good Quality I/M
- Centralised Testing
- Strong Enforcement
- Privatized
- Good Public Awareness
- Appropriate Test Procedures
- Inspector Training
- Appropriate Standards & Norms
- Environment, Oversight & Auditing

### Conclusions

- Air Pollution Causes Serious Health and Environmental Problems
- A Comprehensive Strategy is Needed
- India Has Made Significant Strides But
  - Sulfur in Fuel Still Lags
  - I/M Program Very Ineffective
- I/M Plays A Critical Role
- I/M Improvements Are Underway
  - Loaded Testing of MC A Big Step Forward
  - Diesels Remain Significant Challenge
- The Keys To Successful I/M Have Been Reviewed