

Issues & Challenges for I&C in India

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United States and Europe

Strategy

Promote introduction of new clean vehicles

		PM g/kWh
1992	Euro I	0.36
1996	Euro II	0.25
1998	Euro II	0.15
2000	Euro III	0.10
2005	Euro IV	0.02
2008	Euro V	0.02

EPA..... "Our interest in in-use PM measurement is much more focused on compliance testing for the manufacturers than it is on I/M."

South Asia & Latin America

- Older Truck Population
- Can not wait for new technology to trickle down.
- Emissions must be improved from current vehicle fleet
- Importance of Inspection and Control of Emissions from In-use Vehicles



Main Emissions Challenge: PM

Diesels

- Heavy-duty trucks and buses
- Small population but considerable fuel consumption
- Contribution to PM pollution is far more important than the number of vehicles indicate
- Spectacular growth of diesel cars, SUVs, trucks

2- & 3-wheelers

- Old vehicles
- Large Population: includes 2-stroke
- High growth rate in personal transport

Main Fitness & Safety Challenge

Europe, US & Japan.

- 3 – 5 % of accidents caused by technical defects
- 7 – 18 % of accidents were more severe because of technical defects
- Fitness & Safety Testing can reduce these accidents by 50%
- Require an objective revision of many safety-related points
(Current test is highly subjective)
- Usefully encompass all on-road vehicles.
- Could this be immediately achievable for all vehicles in India?
- Could sufficient investment be made immediately available?
- Would it be more effective to phase the programs introduction?

Phased Approach: Focused I&C

Geographical:

- Largest Cities + long distance bus & truck

Vehicle usage

- Public Service + high mileage: High PM emissions & high risk of Fatalities

Objectivity and transparency

- Program MUST be strictly and objectively applied from Day-One

Acceptable failure rate

- Start with a small sub-set of safety checks + add more over time
- Start with loose emissions limits and progressively tighten

Legislative

- private vehicles + update CMVR rules

Lessons Learnt from Mexico

- Emissions program **must be seen by Public** to be
 - effective,
 - totally objective,
 - transparent and
 - control gross polluters
- Focus on dirtiest (or most dangerous) vehicles
- Enforced, supervised and audited
- False Passes damage public acceptance
- Centralized Test-only inspection
- Use Good Test Procedure
 - Dynamometer testing used to stop cheating / tampering

What is a Good Test Procedure?

- Should not cause clean vehicles to be repaired
- Must not allow dirty vehicles to pass
- Must be easy to perform
- Must be cost-effective
 - The advantages of the program to the public must be seen to be **MUCH** greater than its social cost.
- Must be resistant to tampering and cheating
- Cost of False Pass is a good indicator of Program effectiveness

Diesels: - Visual Smoke

Delhi – Jaipur – Agra, India

- Visual smoke rule

Bangkok, Manila, New Zealand

Mobile Phone and SMS reporting

Hong Kong

- Trained Police Spotters
- From Free Acceleration to Dynamometer lug-down
- Pass rate down from 90% to 15%

PM Emissions of Growing Concern



Free Accel. Test Procedures

SAE J1667 vs ECE R24 standards

- Test Results depend on the Tester
- Even with additional Controls to limit Tampering has Poor Reproducibility in I&M Environment
 - RPM,
 - Oil Temp
 - Master Reference Tables
- Procedures need improvement
- Not effective on recent technology vehicles



Emissions Tests should promote permanent Truck Repair

- Easy to prepare a vehicle to pass a free acceleration test
- 70+% of repairs focus on the engine's Transient Air-Fuel Ratio Control.
 - No Air Pressure (Cummins)
 - Throttle Delay (DDC)
 - Puff Limiter (Mack)
- Often will not reduce Real-life Smoke Emissions

Smoke vs Particulates

- Smoke results depend on drive cycle
- Smoke test can only control visible smoke
- Poor correlation between free acceleration smoke and mass particulate emissions on Dynamometer
- Free acceleration useful as screening tool **BUT** needs lenient standards to minimize false failures.
- Single or two speed dynamometer test easier to operate and more cost-effective

UK's National Audit Office review of I&M program (1998)

- “...had been assumed that the exhaust smoke opacity generated in the Free Accel. Test could identify the maintenance condition of the vehicle”

BUT..

- High number of errors of commission
- Significant variability in the test results.
“If the accelerator is pressed too slowly, the maximum amount of smoke emitted can be reduced by a factor of five.”

ECE Joint Commission Services Study (1994-8)

- “Free acceleration test does not correlate well with any long or short driving cycle, irrespective of its nature.”
- “...[The bad correlation] is largely related to the extreme and indeed unrealistically high transient character of the free acceleration smoke test”

ECE Joint Commission Services Study (1998)

Short dynamometer test found to be:
(measuring average smoke over a dynamic test)

Netherlands

- 38% more cost effective than Free Accel.
20.0 vs 32.4 MECU/kton PM10

Greece

- 42% more cost effective than Free Accel.
1.8 vs 3.1 MECU/kton PM10

Santiago, Chile

Dynamometer test used for urban diesel buses for over 10 years

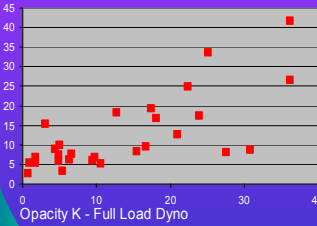


Engine	BHP	Dyno
80 – 120		45
121 – 165		60
166 & over		80

Colombo, Sri Lanka

Full-load Dynamometer Smoke Test more representative of Heavy Truck operation

Opacity K - Free Acceleration

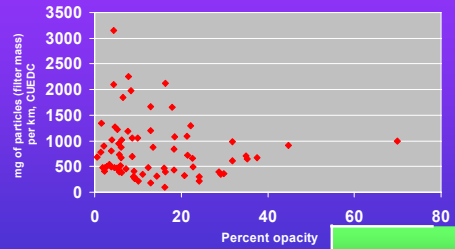


Dynamometer
K (m-1) 25

Free Acceleration
K (m-1) 8 - 34

Australia: Smoke -PM Correlation

Average Smoke Opacity in Snap Acceleration and Mass Particulate Emissions in Loaded Transient Tests



Hong Kong: Conclusions

The dynamometer-based “lug-down” test is far more effective than the free-acceleration test in controlling and permanently reducing visible smoke

CNG

- Fuel switch to reduce PM emissions
- Effect may not be discernable in PM10 concentration data
- Old engineering adage “You can not control what you are not measuring”
- Need to measure Ultra-fine Particle concentrations
- Need to regularly check vehicle emissions (CO, NO, HC) on Short Dynamometer Test

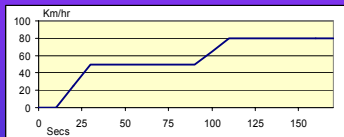
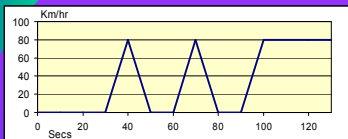
Short Dynamometer Tests

- Steady-state easy to operate
- Repeatable results
- Good correlation with new-vehicle Certification Tests
- Measure Smoke or PM
CO, HC, NO, CO2 & O2 Performance
- **Required** to control false-passes
- More difficult to falsify

Garage Grade



DT80 & AC5080 test cycles



2- & 3-wheelers



Emissions Testing

Static Test

- Easy to cheat
- Little permanent emissions improvement

Dynamometer Test

- ARAI proposed Inertia-only Dynamometer
 - A lot of progress has been made on 2 wheelers but some outstanding issues to be resolved
 - Low Investment but Drive cycle more difficult to operate
- Power Absorber Dynamometer (Eddy Current)
 - Higher initial cost and complexity
 - Constant-speed test fully developed and easier to operate

Are there other options?

Fixed-location Remote Sensing



- Very High Capacity
- Measure CO, HC and Opacity Ratio
- Concentration measurements
- Would require operational testing



Conclusions

- Static tests promote false passes

Diesels

- Smoke can be controlled visually
- Free Accel Smoke is not a surrogate for PM
- Short Dynamometer tests are better for identifying gross polluters in developing countries

CNG & LPG

- Need to monitor regularly on Dynamometer

3-wheelers

- Short loaded Dynamometer tests are cost-effective and better technically
- Fixed-location remote sensing could be developed

Thank you

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