

The New PIARC Tunnel Air Emissions Standard

Dr Fathi Tarada

PIARC Working Group on Air Quality, Fire and Ventilation



Motivation

- Air quality is an important criterion for tunnel ventilation
- Design emissions data requires updating
- Reconsideration of critical pollutants
- Guidelines for developing countries & countries in transition
- Improvements in the design, specification and operation of tunnel ventilation

Authors

The authors of the PIARC report on “Road Tunnels: Vehicle Emissions and Air Demand for Ventilation” are

- Rune Brandt (Denmark/Switzerland)
- Romano Borchiellini (Italy)
- Bruce Dandie (Australia)
- Arnold Dix (Australia)
- Massimiliano Fresta (Italy)
- Frédéric Hervé (France)
- Mathias Henn (Austria)
- Norris Harvey (USA)
- Peter Sturm (Austria)
- Franz Zumsteg (Switzerland)

Agenda

1. Background

2. Critical Pollutants

3. Vehicle Emissions Standards

4. Calculations Procedures

5. Summary

6. Conclusions

1. Background

Purpose of Tunnel Ventilation

- To control smoke movement in case of a fire within a road tunnel (*usually the dominant factor*)
- To ensure adequate air quality within a road tunnel, during normal and congested operation (*may be dominant in highly trafficked urban tunnels*)

The current report only addresses air quality issues, not smoke control.

Previous PIARC Reports

- **Report from 2004** “Road Tunnels: Vehicle Emissions and Air Demand for Ventilation”
- **Report from 1995** “Vehicle Emissions - Air Demand, Environment, Longitudinal Ventilation”

New report replaces both previous reports.

2. Critical Pollutants

Critical Pollutants

- Fresh air demand is estimated based upon in-tunnel production of critical pollutants:
 - Carbon monoxide (CO)
 - Visibility (suspended dust)
 - NO_x (including NO₂)

Need to reduce the pollution concentrations to acceptable levels.

Carbon Monoxide (CO)

- Traditionally taken as the **reference emission** for the assessment of the toxicity of exhaust gases
- Declining in importance due to
 - Improvements in engine design
 - Increasing proportion of diesel-powered vehicles

Visibility & Dust

- **Vehicle exhaust** (mostly from diesel engines) consists of very small particles mainly in the range of 0.01 to 0.20 μm . Particles in this range are very effective in light extinction.
- Also: particulate matter due to **abrasion processes** (road, tires, brake wear, etc.) and **re-suspension of road dust** (1 μm and upwards – less effect on visibility)

Nitrogen Oxides

- **NO₂ is noxious** and can irritate the lungs and lower the resistance to respiratory infections such as influenza.
- **Better engine design** reduces nitrogen oxide emissions, *but*
- Implementation of diesel vehicle exhaust gas after-treatment systems increases proportion of **NO₂ from 10% up to 30%**

DESIGN AND THRESHOLD VALUES

Traffic situation	CO	Visibility/Extinction	Visibility/Transmission
	ppm	10^{-3} m^{-1}	% (beam length 100m)
Free flowing peak traffic 50 –	70	5	60
Daily congested traffic, stopped on all lanes	70	7	50
Exceptional congested traffic, stopped on all lanes	100	9	40
Planned maintenance work in a tunnel under traffic	20	3	75
Threshold values for closing the tunnel	200	12	30

3. Vehicle Emissions Standards



Vehicle Emissions Standards

- **Regional & national variation** in emissions standards
- **EC EURO-standards** implemented in Europe, in many countries of Asia (except Japan and South-Korea) and in a few countries in South America, Africa and the Arabic countries.
- **Euro 5** effective 1st Jan, 2010 and **Euro 6** effective 1st Jan, 2014.

Evolution of Euro Standards

	Valid	CO	HC	NOx	HC+NOx	Particles	
		[g/km]					
ECE R 15/03	1979	21.5	1.8	2.5		smoke number	
ECE R15/04	1982	16.5			5.1	smoke number	
US 83*	1987	2.1	0.25	0.62	0.373		
PC Euro 1	1992	2.72			0.97	0.14	
PC gasoline EURO 2	1997	2.2			0.5		
PC gasoline EURO 3	2000	2.3	0.2	0.15			
PC gasoline EURO 4	2005	1.0	0.1	0.08			
PC gasoline EURO 5	2008	1.0	0.100	0.060	0.068	0.005	
PC gasoline EURO 6	2014	1.0	0.100	0.060	0.068	0.005	

Vehicle Emissions Standards

- US emissions standards: National “Tier II” standards (from Environmental Protection Agency), Californian Air Resources Board (CARB)
- Other countries and regions have their own emissions standards.

International Survey

- Questionnaires sent out to World Road Association member countries
- Based on the information received, emission factors for certain countries were derived (**Australia, Algeria and China**)

Emissions Tables (Example)

TABLE 9: BASE EMISSION FACTORS FOR NOX (EC EURO- REGULATION) DIESEL PASSENGER CARS

PC Diesel NOx [g/h] 2010							
	Gradient [%]						
v [km/h]	-6	-4	-2	0	2	4	6
0	6.3	6.3	6.3	6.3	6.3	6.3	6.3
10	6.3	6.3	6.3	11.5	15.8	19.6	23.6
20	6.3	6.3	7.2	16.5	23.0	28.3	36.6
30	6.3	6.3	9.3	20.9	28.6	38.7	51.7
40	6.3	6.3	10.0	24.0	34.6	49.9	68.2
50	6.3	6.3	9.0	25.7	40.7	61.6	83.7
60	6.3	6.3	10.7	28.6	50.3	76.3	103.9
70	6.3	6.3	14.2	34.7	62.5	92.9	127.9
80	6.3	6.3	19.4	43.1	76.4	113.1	154.1
90	6.3	6.3	24.7	54.0	91.9	135.9	182.6
100	6.3	6.3	31.3	68.4	112.5	162.7	215.2
110	6.3	7.9	41.7	85.6	137.2	193.1	251.6
120	6.3	20.0	56.8	107.2	165.8	227.7	292.2
130	6.3	30.1	76.3	134.4	199.0	266.9	337.6

4. Calculations Procedures

Emissions Calculations

- Previous PIARC emissions calculations were based on the projected **vehicle-fleet distribution** (passenger cars, light duty vehicles and heavy goods vehicles) and individual emission standards
- However, this information is not always readily available in developing countries and countries in transition

Changes Proposed

- In addition to previous calculation scheme, a simplified scheme based on **Technology Standards** will be proposed.
- Use **2010 as the base year** adjusted with country-specific influencing factors concerning different design years, emission standards, etc.

Technology Standards

Technology standard A:

- Covers the European Union, USA and countries with similar vehicle emission standards.

Technology Standards

Technology standard B:

- Countries which have adopted Euro or similar emission standards with a time shift of 10 years.

Technology standard C

- Countries which have adopted emission standards but don't conduct any effective emission control.

5. Summary

Summary

- Complete review of previous PIARC recommendations on air quality demands
- Increasingly, NO_x and dust are becoming more critical than CO for tunnel air quality
- New scheme proposed with 'technology standards' to supplement vehicle-specific calculations.

Summary

- Some details of the new standard are available to download via

mosenltd.com/news

6. Conclusions

Conclusions

- The new PIARC standard is aimed to improve air quality in tunnels worldwide
- Will be published later this year (2011)
- Please use it and feed any comments back to the PIARC Secretariat!