Tunnel air emissions

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Tunnels do not generate emissions – rather, they confine and redistribute emissions given off by vehicles passing through them. Instead of being emitted into the outside environment along the road length, airborne pollutants are discharged at tunnel portals, or through ventilation stacks. Depending on whether a rural or urban environment is under consideration, and how effectively the emissions are dispersed, there may be a concern whether air quality standards will be respected. These issues are discussed in a new report by the World Road Association (PIARC), that is about to be published.

PIARC's 'Guide to Optimising the Air Quality Impact upon the Environment' discusses a range of opportunities to enhance the urban environment by altering the emissions from vehicles and changing their spatial distribution. These opportunities include selecting the optimum location of a tunnel, minimising carriageway gradients, designing an appropriate ventilation system, controlling the discharge of vitiated air into the environment, managing the traffic, maintaining tunnels and removing contaminants (including filtering the air). This guidance supplements PIARC's previous report on 'Road Tunnels: Vehicle Emissions and Air Demand for Ventilation' published in 2004, which dealt with air quality requirements within tunnels.

Motor engines emit a range of pollutants which may be harmful to human health and the environment, including carbon monoxide (CO), nitrogen oxides (NOx), particulate matter, hydrocarbons and lead (in countries where lead is still permitted as an additive to petroleum fuel). Particulate matter that is 10μm or less in diameter is also generated by the wear on rubber tyres and brake pads.

The physiological and environmental effects of vehicular emissions are reasonably well known, although research work is still underway to understand the details. Carbon monoxide poisons by displacing oxygen from the bloodstream, and hence putting the functions of the heart, brain and other vital organs of the body at risk. However, due to employment of catalytic converters in petrol engines, and the shift to diesel engines, carbon monoxide emissions have been falling significantly in recent years, to the extent that this particular pollutant is no longer considered a critical determinant of roadside air quality. Instead, nitrogen oxides and particulate matter are now of greatest concern to policy makers and designers.

Nitrogen dioxide (NO_2) affects the human respiratory response, especially for asthmatic individuals, whose response to allergens can be negatively enhanced. NO_2 is produced as a direct result of engine combustion, and also as a product of the oxidisation of nitric oxide (NO) in the presence of ozone (O_3) and sunlight. The introduction of emission standards such as Euro 4 and Euro 5 for heavy goods vehicles (mandatory from 2006 and 2009 in Europe), are due to substantially decrease the emissions of nitrogen oxides.

Guideline limits for NO and NO_2 in tunnels can be somewhat controversial. In the UK, the Health and Safety Executive (HSE) has withdrawn its Chemical Hazard Alert Notices, which proposed a limit of 1 part per million (ppm) for both NO and NO_2. Tunnel operators had complained that the proposed limits would not be feasible or practical to meet. The short-term (15 minute) occupational hazard limits set by the HSE in 2002 for NO and NO_2 are 35 ppm and 5 ppm, and these limits are still used by tunnel designers in the UK, pending updated guidance.

Routine in-tunnel measurements of NO_2 have recently become possible, due to the development of a number of new technologies, including differential optical absorption spectroscopy. This will make the control of tunnel ventilation based on real-time NO_2 measurements a viable proposition. Previously, tunnel ventilation control during normal operation was based on carbon monoxide and visibility sensors.

Particulate matter affects visibility levels within tunnels and at locations where the tunnel air is discharged (portals, ventilation stacks), and can contribute to the development of smog. There is evidence that the inhalation of sub-microscopic particles is associated with breathing difficulties and cancer. Unfortunately, the recent trend towards diesel-powered engines has exacerbated the potential health risks, since diesel engines generally exhaust more particulate matter than petrol engines of equivalent power.

The health risks of tunnel emissions must be viewed in the appropriate context – tunnels comprise a very small percentage of the overall road network, both in terms of kilometres and in terms of the time that the motoring public travels through them. There is usually a net benefit to overall air quality when traffic is diverted underground, since the exposure of people to airborne pollutants at ground level can be reduced.

New technologies are now available to improve the air quality within and outside tunnels. For example, the M30 Madrid Calle 30 project, which is due to reconstruct 99km of motorway, including 28km of tunnels in the west area, has elected to install electrostatic precipitators to reduce particulate matter from tunnel emissions. NO_2 will be removed catalytically using activated carbon filters, and it is claimed that the majority of volatile organic compounds will also be filtered out. In any such installation however, there will be significant energy and maintenance costs – and the energy consumption of the precipitators leads to additional carbon emissions. A careful assessment of the overall costs and benefits, both monetary and environmental, of any technology for tunnel air quality improvement is always recommended.