

A STEP FORWARD FOR FRESH AIR

Fathi Tarada, managing director of Mosen, reviews a new emissions guidance report issued by the World Road Association

THE WORLD ROAD ASSOCIATION (PIARC) has just issued a new report on "Road Tunnels: Vehicle Emissions and Air Demand for Ventilation", which is available to download free of charge from the PIARC virtual library (www.piarc.org). I am a member of the PIARC Technical Committee on Road Tunnel Operations, and undertook the peer review of the document.

The required ventilation capacity for most road tunnels is set by reference to emergency conditions, namely the provision of sufficient airflow to control the movement of smoke in a fire emergency, rather than by any consideration of air quality. In certain warm countries such as Singapore, the required ventilation capacity is set by

Below: Road tunnel ventilation should consider requirements for air quality at all times, and not just in emergency situations

reference to the maximum temperature that is tolerable to motorcyclists. However, the amount of fresh air required to dilute pollutants during normal and congested operation, or to satisfy special environmental constraints, can be dominant in tunnels with high traffic volumes and frequently congested traffic.

The new PIARC report provides detailed guidance on the volume of fresh air required to dilute airborne pollutants in road tunnels (carbon monoxide CO, nitrogen dioxide NO₂, and particulate matter) down to tolerable limits. Compared to the 2012 PIARC publication on the same subject, vehicle legislation has enforced more stringent emission rates, and emissions technology has rapidly advanced. The majority of the report comprises tables of the variation of emission rates with respect to vehicle speed and gradient.

Given the controversy surrounding the Volkswagen emissions scandal (and other similar scandals), PIARC was careful to provide a report that relies on tests on chassis dynamometers and the application of on-board measurement devices. The report is therefore intended to describe the real-world emission behaviour of on-road vehicles in road tunnels. As a further measure to



ensure correspondence with reality, a conservative approach was taken where emission factors may lie within a range. The new report completely supersedes the 2012 PIARC publication on road tunnel emissions, hence the latter should no longer be used.

The main changes from the previous PIARC report concern the emission data up to 2030 for Euro 4, 5 and 6 vehicles as well as an update of the factors for non-exhaust particle emissions. Additional data for Light Commercial Vehicles are provided for diesel and gasoline fuelled vehicles separately.

Two approaches to estimating vehicle emissions for a particular design year are detailed, both using 2018 as the base year for the emission rates:

- The standard approach is based on the emission estimations for the base year and the application of different influencing factors for year of operation, altitude of the tunnel, and vehicle mass (for HGVs only).
- The fleet-specific approach allows an emission calculation, when the vehicle fleet data are known in detail, using specific tables for emission rates for single vehicle model years. This method is applied if the fleet composition is different to that assumed for the standard approach.

As a simplified approach, emission generation rates have been grouped into three technology classes (A, B, C) with similar emission standard distributions in their fleets. "Technology class A" data follow a fleet distribution found in Western Europe or North America. These countries require vehicles to be checked regularly for emissions compliance, including exhaust emission measurements through regular vehicle inspections.

"Technology class B" is used for countries which have adopted Euro or similar emission standards with a time shift compared to technology class A. "Technology class C" applies to countries which have adopted delayed emission standards but do not conduct any effective emission control (i.e., vehicle inspection programs) of vehicles.

The emission rates are a function of several factors including:

- the number and type of vehicles (passenger car, large commercial vehicle, heavy goods vehicle),
- the emission standard under which the vehicle was registered (e.g. Euro 4),
- vehicle speed which includes congested or fluid traffic,
- road gradient,
- other parameters influencing the power needed to propel the vehicles (e.g. weight).

The emission rates provided in the report are based on the year 2018. Due to the continual renewal of the vehicle fleet, emission projections for future years must consider improvements in vehicle emission quantities. Therefore, reduction factors are provided for years projected later than 2018.

The total emission rate for a given year is determined by the addition of the emission rates for each vehicle type, under an assumed distribution of vehicle ages in the fleet.

This report defines two different approaches for determining emission rates for individual vehicle types. The standard approach uses predefined fleet averaged emission rates. This approach is for countries that follow similar implementation of emission standards and vehicle age profiles when compared to countries with known emission values (e.g., EU or North America). The fleet-specific approach is to establish the specific implementation of emission standards within the country of interest. Emission rates can then be determined if the age and distribution of the vehicle class (Euro standards) is known. The vehicle-specific approach can be more accurate but requires more detailed knowledge of the individual fleet distribution in terms of emission standard classes.

A large uncertainty exists for the quantification of non-exhaust particulate matter emissions (re-suspension of road dust, abrasion). Production of such non-exhaust emissions depends significantly on the overall cleanliness of the tunnel, the types of vehicles and the goods transported through the tunnel as well as on the traffic operation mode (uni- or bi-directional traffic). The report provides some guidance for the estimation of such non-exhaust emissions.

The emission rates provided in the PIARC report are intended for ventilation calculation design purposes. However, these emissions rates tend to be conservative for carbon monoxide and particulates (visibility) compared to emission data used for the assessment of the environmental impact on external air quality.

A key determinant of air quality in tunnels is now recognised to be NO₂ concentration. NO₂ is noxious and can irritate the lungs and lower the resistance to respiratory infections such as influenza. For short-term exposure, the 2015 WHO Expert Consultation reported evidence of a causal relationship between short term NO₂ exposure and respiratory health impact. The US National Institute for Occupational Safety and Health (NIOSH) proposes a value of 1 ppm as a 15-minute short-term limit.

Although the 2012 PIARC report on air emissions proposed a threshold value for in-tunnel NO₂ of 1 ppm as an average figure over the tunnel chainage, this value has not been adopted in the current PIARC report. Instead, the report provides examples of international regulations. France has introduced a threshold value of 0.4 ppm NO₂ as an average over the tunnel length, while New South Wales in Australia has proposed a value of 0.5 ppm NO₂ as a tunnel route average. Such low threshold values for NO₂ imply a significant increase in tunnel ventilation capacities compared to the previous PIARC guidance. The situation is especially onerous in Australian tunnels, where the combination of a low threshold NO₂ limit and the requirement for "zero portal emissions" leads to ventilation capacities and power consumption values that far exceed European levels. The PIARC report does not address how air quality issues should be balanced by sustainability considerations.

In conclusion, the new PIARC report on vehicular emissions is a major step forward for the assessment of fresh air demands in road tunnels. It is likely to be used by tunnel designers, contractors, consultants, operators and statutory authorities for many years to come.