This month Keivan Rafie highlights the basic requirements of ventilation for tunnels in operation and under construction.

Tunnels require ventilation for a variety of reasons – to ensure adequate air quality, control the spread of smoke in case of a fire, or reduce temperatures. Fresh air must be supplied to all underground work areas in sufficient amounts to prevent any dangerous or harmful accumulation of dust, fumes, mist, vapors, or gases. Vehicular tunnels (road, rail and metro) generally require high air quality during normal operation and smoke control in case of fire; while cable tunnels require cooling, smoke control and a certain amount of air exchange. Tunnels under construction also require adequate ventilation for physiological, cooling and smoke control requirements.

The principles of a ventilation system are classified into the air-supply and the air-exhaust systems and the application method is classified into the face-concentration system and the series connection system.

The main aspects that need to be considered for appropriate design of a tunnel’s ventilation and cooling system are the removal of the pollutants (exhaust, blasting fume, dust), and establishment and maintenance of a climatic state (temperature, humidity) in accordance with the required physical activities of the workforce on the site.

The discharge volume of ventilation in a tunnel is calculated considering these parameters: Tunnel dimensions, discharge volume of ventilation per one person and each equipment/engine, maximum number of people and equipment in the tunnel and any extra capacity needed for drilling, blasting, traffic and shotcrete operations.

The air velocity is usually measured using an anemometer and stopwatch. Air velocity produces a wind chill factor, which lowers the apparent temperature, giving the sensation of being exposed to a lower temperature than in actuality.

Auxiliary ventilation is the provision of ventilation to development ends, stops, faces, headings and services facilities, which constitute secondary circuits tapped off the primary circuit or main through flow of air. These circuits may be blind, parallel or in series.

Ventilation pipes used in tunnel are classified into hard pipe and soft pipe. Soft pipe is portable and flexible but less rigid therefore the negative pressure by suction reduces its cross section. In this case, steel reinforcement rings shall be installed inside the pipe. Hard pipe is rigid and durable and has small friction loss but it is relatively more expensive and harder to install.

Types of fans: (a) Main fans, create the primary ventilating pressure, either forcing or exhausting, generating the ventilation circuit around the mine. (b) Auxiliary fans, generate air flow beyond the circuit created by the main and booster fans. These fans are used in headings and developments. (c) Booster fans, are located underground and reduce the pressure that should be generated by the main fans in mines with complex underground workings. And (d) Scrubber fans, remove dust by passing air through a filter.

Chemical symbols for gases commonly discussed in tunneling: Methane (CH$_4$), Carbon Monoxide (CO), Carbon Dioxide (CO$_2$), Hydrogen (H$_2$), Hydrogen Sulfide (H$_2$S), Nitrogen (N$_2$), Oxygen (O$_2$), and Sulfur Dioxide (SO$_2$).

Methane is flammable when mixed with oxygen in a wide range of concentrations, but generally between 5-15 per cent methane in air by volume. Concentrated methane tends to collect in roof cavities and layer along roofs of airways or working faces because it is buoyant and rises in air.

The choice of fuel for in equipment can have a significant impact on both the quantity and quality of the emissions produced by the engine. Different fuels and fuel types can have disparate emissions profiles (e.g., particulate size, distribution, gaseous fractions, etc.) and may also impact the scope and applicability of other emissions controls.

The accurate determination of dust concentrations in any underground environment is both difficult and imperative to effectively quantify and control exposure of harmful levels to the workforce. This task is made considerably more difficult by the varied nature with which dust is generated throughout the tunnel, and the many locations that both the dust source and the worker may travel in any given shift.

Suggested reading

- Tunnel air emissions, Fathi Tarada
- Ventilation System in Tunnel during Construction Works, Yoshihiro Takano
- Tunnel Construction Site Ventilation and Cooling: Uwe Drost, Marco Bettelini
- Ventilation-in-underground-mines-and-tunnels (NZ Government Guidelines)
- Establishing Total Airflow Requirements for Underground Metal/Non-metal Mines (J. Daniel Stinnette)

Agree or disagree?

Let us know what your experience has taught you. Or let us know what topic should be included in future Rules of Thumb columns. editor@tunnelsonline.info