

Application Report

Visibility in Road Tunnel

High visibility in road tunnel tubes is an essential criterion for the layout of the ventilation system under normal traffic conditions, i.e. free-flowing, stop-and-go, congested traffic. A continuous assessment of the visibility serves as the main control variable for the correct and efficient operation of the tunnel ventilation during such traffic conditions. Visibility is impaired by particles resulting from combustion and by other particles. These other non-combustion particles originate from abrasion (brakes, tires) and re-suspension (swirling fine dust particles). During winter application of road salts also adds to the problem.



Picture: Section through a ventilation layout

Benefits

Road tunnel ventilation is required to ensure that good visibility is maintained allowing motorists to travel safely at any time of the day or the night and irrespective of the traffic conditions. Furthermore, pollutants (toxic emission, particles) have to be continually removed from the tunnel during such ventilation.

Typical application

In tunnel ventilation, the extinction coefficient „K“ has become the customary measure for visibility. Most countries provide values for normal operation in their directives for the layout of tunnel ventilation. These lie typically at a value of $K_{lim} = 0.005 \text{ m}^{-1}$ or 5mE/m (milli-extinction per metre). At a visibility of 12mE/m, the tunnel has to be closed for safety reasons.



Picture: Decreasing visibility over distance

To put it simply, 1mE/m means a reduction of light intensity by a factor 10 over a distance of 1.000 metres.

The ventilation systems installed in road tunnels are equipped with variable volume flows. This allows the adjustment of the ventilation to continually changing traffic conditions. The control system is based on visibility measurement, often in combination with other measurements (CO, NO, wind speed) and helps to minimize the enormous energy costs of the ventilation, thereby optimising the operation.

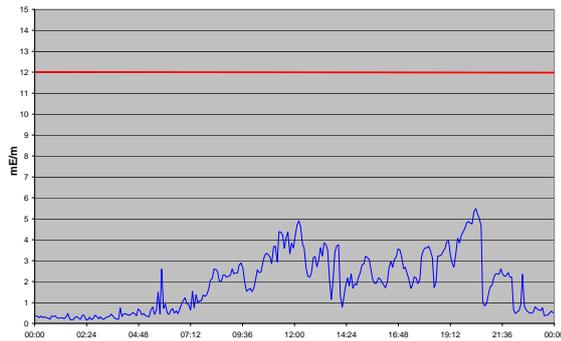
The SIGRIST visibility monitor VisGuard has been designed in accordance with the requirements in road tunnels in such a manner that all requirements as regards kind of installation, corrosion resistance and maintenance intervals are fulfilled. The instrument is available for installation directly in the tunnel tubes (in-situ), as well as for mounting in separate rooms (extractive).

The presence of fog influences visibility measurements and needs to be eliminated. Optional heaters successfully suppress these influences and are mostly used in the tunnel portal area.



Picture: Installation of VisGuard extractive with heater

Practical measurement (example):



Picture: Daily pattern of the visibility in a road tunnel

The above diagram shows the typical pattern of visibility during 24 hours. During those hours of the night with little traffic, the values are around or even $< 1\text{mE/m}$. During this time, the ventilation can be reduced to a minimum. At around 7 o'clock in the morning, the values increase continually and reach a maximum around midday. In the afternoon, the volume of traffic varies and reaches another peak late in the evening. Afterwards the volume of traffic and also the visibility values drop during the night. The red line marks the threshold value for closing the tunnel.

Cost-benefit analysis

The cost of energy for ventilation control is by far the largest proportion in the operating costs of a road tunnel. For the 17 kilometres of the Gotthard tunnel, the total yearly energy consumption amounts to approx. 14.5 Mio. Kwh. About 86% of the energy is consumed by the ventilation, while only 4% of the energy is used for the illumination. With the installation of the VisGuard, the ventilation can be controlled in such a manner that the ventilation can be substantially reduced or even completely turned off at times of little traffic while at the same time the contaminants are sufficiently eliminated and the visibility is guaranteed in accordance with the existing directives.



Picture: VisGuard Mini-extractive installed in an SOS-niche

Products

SIGRIST product and configurations for this application:

- VisGuard in-situ or
- VisGuard extractive
- Sampling system (for VisGuard extractive)
- SIREL, SIPORE PB or SIBUS control unit – depending on configuration
- Checking rod
- Optional: sample heater, heater mountings, valve unit (for VisGuard extractive)

Parameter settings

- Selection of the desired range of measurement (typical: 0 .. 15mE/m)
- Setting of the desired threshold values for preliminary and main alarm
- Further parameter adjustments as required

Advantages of the SIGRIST VisGuard

- Compact design, simple installation
- In-situ, extractive or mini-extractive installation possible
- Flexible system connection
- Energy saving LED light source
- Simple recalibration with checking rod
- Reliable fog suppression
- Low cost of ownership



Picture: VisGuard In-situ (transparent representation)