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VENTILATION COMBINED WITH AIR CLEANING TECHNOLOGY FOR PARTICLES AND NO_X FOR ROAD TUNNELS

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Summary

In Norway, we have extensive experience with longitudinal ventilation of road tunnels. Long tunnels and tunnels with high traffic volume in densely populated areas, however, require new solutions.

On the national highways in Norway, approx. 700 tunnels are under traffic, amounting to a total distance of 575 km. The longest one is the Gudvanga Tunnel, situated in Sogn og Fjordane in western Norway, with a length of 11.4 km. Another tunnel of 24 km is now under construction in the same area.

1. General Information on Norwegian Tunnel Ventilation

The majority of the tunnels have the most simple form of longitudinal ventilation, namely portal to portal ventilation. Lately, however, environmental considerations have caused the construction of tunnels of a greater length, as well as many new tunnels in urban areas with a high traffic volum. If necessary, a tunnel is divided into ventilation sections by use of shafts or side adits. This makes it possible to renew the air inside the tunnel. New technology also makes it possible to clean the polluted air in sections along the length of the tunnel.

In 1989, a research programme was started in Norway to determine the possiblilty of cleaning polluted tunnel air. As a result of this, the technology for extracting particle pollution with a high extraction rate is now used. In Norway we have installed full scale equipment for particle cleaning in 6 tunnels from 1990 to 1996. All these tunnels have solutions based on the use of electrostatic filters. The main purpose with some of these installations was to reduce the emission from the tunnel portals, whereas with others the main purpose was to improve visibility inside the tunnels.

A pilot system removing NO_2 gas has been installed in the Oslo tunnel since 1992. So far, after running continuously for approximately three years the cleaning system for removing NO_2 gas seems to be very promising, with a high efficiency. We are now extending the technology also to remove NO-gas.

In the 24 km long road tunnel we will install jet fans for longitudinal ventilation without shafts. In this case, we will use new technology for cleaning polluted air in a cleaning circuit inside the tunnel, for both particles and No_x-gas.

2. Experience from use of Particle Cleaning Systems

So far, the Public Roads Administration has installed equipment for particle cleaning in five tunnels, from 1990 to 1996. All tunnels have solutions based on the use of electrostatic filters combined with mechanical filters.

At present, the following tunnels are equipped with particle cleaning plants:

- The Oslo Tunnel (installed in connection with the ventilation tower)
- The Granfoss Tunnel (bypass)
- The Ekeberg Tunnel (bypass) northbound
- The Ekeberg Tunnel (bypass) southbound
- The Hell Tunnel (installation in the ceiling)

The purpose behind installing particle cleaning systems in these tunnels varies slightly:

In the Oslo Tunnel the purpose was to reduce the particle pollution on the environment, in the tunnel's neighbourhood.

In the Granfoss Tunnel and the Ekeberg Tunnels the purpose was to reduce the emission from the tunnels as well as to improve visibility inside the tunnels.

In the Hell Tunnel, which is the only one of these tunnels with two way traffic, the purpose was to improve visibility in order to obtain better driving conditions and traffic safety.

I will present a more detailed description of the tunnels in question and describe the solutions which have been selected for particle cleaning.

2.1 Gas Cleaning

Research was started in 1992 to determine the possiblility of cleaning NO_x. A pilot plant was installed in the Oslo tunnel.

For this purpose we use a special type of activated carbon catalyst and the NO_x gas is injected with ozon and ammonia to convert the NO part of NO_x into NO_2.

The cleaning process is a combination of a catalytic reduction process and absorbtion process.

So far, results from measurements show a reduction of the NO_x concentration after cleaning of approximately 70%. After the cleaning process we cannot measure concentration of NO_2 at all. We are still working on this process, but we assume that research will be finished in 1997, and we are very optimistic regarding this solution.

2.2 The Oslo Tunnel

The Oslo Tunnel is a highway tunnel under the centre of Oslo, consisting of two tubes with six traffic lanes.

The length of each tube is approximately 1800 m. The annual average daily traffic today is approximately 70000 - 80000 vehicles/day. Both tunnels have a longitudinal ventilation system, with a vertical shaft at the end of each tube to reduce emission of polluted air from the tunnel portals.

The ventilation capacity is about 1000 m^3/s in each tube.

In connection with one of the ventilation towers, electrostatic filters have been installed to extract particles before the air is emitted through the ventilation tower. The principle is illustrated in Fig.1.

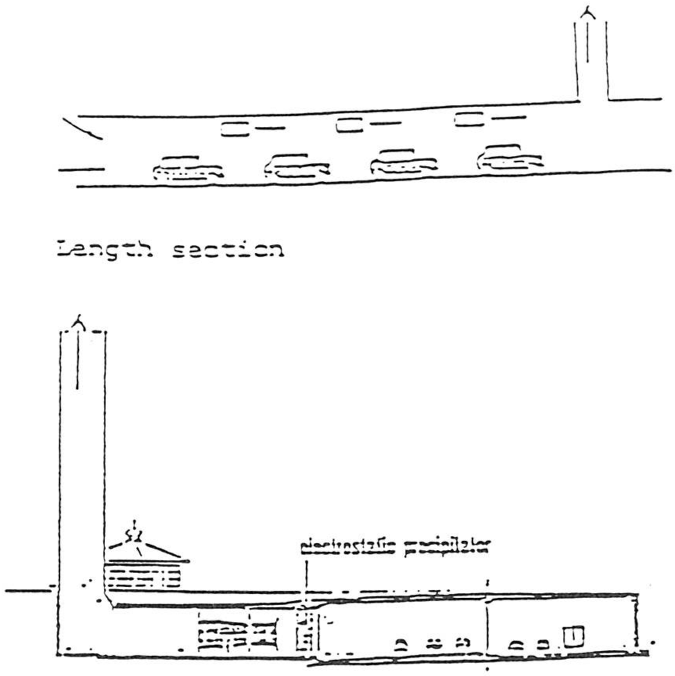

Fig. 1 Principle for installation of electrostatic filters in the Oslo Tunnel

The capacity of the air cleaning system is 600 m^3 air/s.

In order to improve the air quality in the city, polluted air from one tube is cleaned before entering the tower. Even with ventilation towers for discharge of polluted air, the spread of particles is a problem in the outside area around the towers.

Since the opening of the tunnels, the pollution has been monitored into and out of the tunnel. We have also monitored pollution intensity at different points in the city. These measurements have given information on the concentration of particles before and after the tunnels were opened. Experiences so far veryfy that the cleaning system has a positive effect on the area around the ventilation tower. The test in the Oslo tunnel shows that it is very effective to extract particles before emission through the ventilation tower. This in turn implies a clear positive effect on the environment surrounding the emission point.

2.3 The Granfoss Tunnel and the Ekeberg Tunnels

In these tunnels a bypass inside the tunnels has been selected for extraction of particles instead of a ventilation tower. This solution, where the air is cleaned inside the bypass tunnel, has considerable advantages compared to the construction of a ventilation tower. The project planning procedure is very much simplified without the need to implement a ventilation tower for emission of polluted air.

The Granfoss Tunnel is approximately 1000 m long, with an AADT of 15000 - 20000 vehicles/day.

The Ekeberg Tunnel is approximately 1500 m long with an AADT of 50000 vehicles/day.

The Granfoss Tunnel and the Ekeberg Tunnels each have two tubes with one way traffic.

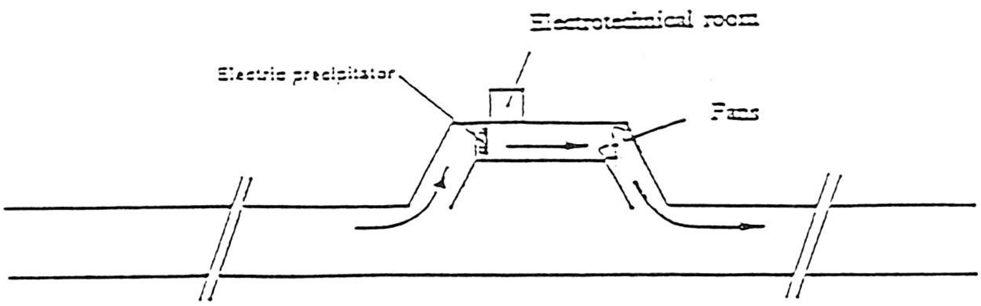

Fig. 2 The principle for a bypass solution selected in the Granfoss Tunnel and the Ekeberg Tunnels

The main purpose behind selecting this type of solution in the Granfoss Tunnel as well as in the Ekeberg Tunnels, was to achieve better visibility in the tunnels, and to reduce the pollution and emission of particles to the area surrounding the tunnel portals. In all three tunnels, the length of the bypass behind the electrostatic filter is designed to have sufficient space for the installation of a plant for clearing of nitrous gases.

2.4 The Hell Tunnel

Current research on different types of electrostatic filters shows that certain filters have a high extraction rate with an air velocity as high as 7 m/s. By increasing the air velocity through the filter, without renunciation of cleaning effectiveness, the necessary filter area to clean the same volume of polluted air can be reduced. This will reduce the construction and installation costs. Increased allowable air velocity will in some cases also make it acceptable to install the cleaning units in the tunnel ceiling, provided that the air volume to be cleaned is not to large.

The Hell Tunnel is 3880 m long, has two way traffic in one tube, and a traffic volume of approximately 10000 vehicles/day.

In this tunnel electrostatic filters were installed in the tunnel ceiling at points along the tunnel as shown in Fig. 3.

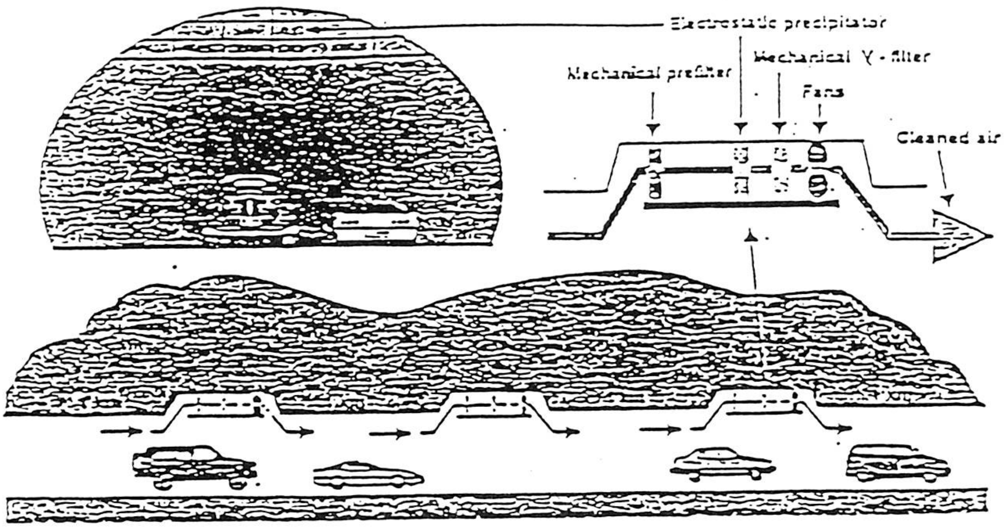

Fig. 3 Principle for installing electrostatic filters in the Hell Tunnel

Cleaning equipment is installed at three points along the tunnel. The distance between the stations is approximately 1000 m. The capacity is 100 m^3 air/s at each cleaning station. The air velocity through the electrostatic filter station is 7 m/s.

This solution has been selected with the purpose of improving the visibility inside the tunnel, but the solution will also reduce the emissions to the area surrounding the tunnel portal.

By an efficiency of 90% of the particles passing through the electrostatic filter we expect a practical extraction rate of 70% of particles in the tunnel following the cleaning station.

Measurements to decide the extraction rate by this solution will be made and completed during the winter/spring 1997.

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