Evaluation of Ventilation Performance in a Subway Station - Using Freon 134a as a Tracer-gas

Application Note

The Problem

The air quality in a subway station with many diesel trains sets high demands on the ability of the ventilation system to remove obnoxious gases and particles.

In a big Danish subway station, which services regional, local and metro trains in three different sections, the management wanted to evaluate the performance of the ventilation system to assure good air quality at the platform. Along the 200 metre long platform, there are located 43 vents, which supply outdoor air to the occupied zone. The exhaust vents are placed in the ceiling above the trains. The platform in question serves both diesel and electric powered trains. The influence of openings to both the outside and other parts of the subway system affect the performance of the ventilation system, and complicate the quantification of its performance. With the arrival and departure of trains, the piston effect creates high air velocities in the stairwells and tunnels, which leads to large air changes.

Fig. 1 Monitoring CO, CO_2 and Freon 134a in a subway station in Copenhagen

The Monitoring Need

In order to evaluate the ventilation system and air quality in the subway station, it was necessary to use two tracer-gas monitoring systems: one stationary system for dosing the tracer-gas in the ventilation system and one mobile system for measuring at the same time. Freon 134a was used as the tracer-gas because SF_6 is forbidden in Denmark due to its high Global Warming Potential, GWP-index. (The GWP index for F134a is 1 300, while the GWP-index for SF_6 is 23 900). For the evaluation of the air quality, CO and CO_2 were also measured at various locations in the subway system.

INNOVA's Solution

The Photoacoustic Multi-gas Monitor 1312 is well suited for these types of measurements. The monitor is easily operated and can measure the 3 gases of interest within one minute.

Due to the distance between the dosing point at the air intake and the various sampling points around the station, two independent systems were used. For measuring the CO, CO_2 and Freon 134a concentrations in the various sections of the station, one Photoacoustic Multi-gas Monitor 1312 was used. When connected to an inverter and a car battery this system is fully mobile. For dosing of the tracer-gas, a Multi-point Sampler and Doser 1303 is used with a 1312 and the Application Software 7620. The system is set up with a constant dosage rate of Freon 134a. This occurs in the ventilation inlet just before the fan and ensures a good mixing before the air was distributed to the platform. Using the tracer-gas technique, where the ventilation air is "marked" with a detectable tracer, which is not present in the atmosphere, it is possible to detect how well different sections of the platform are ventilated. Furthermore, it is possible to measure the spreading of pollutants to other parts of the subway system, by measuring the traces-gas concentrations at these locations.

Fig. 2 Photoacoustic Multi-gas Monitor 1312

Fig. 3 Dosing and sampling Freon134a

Measurement Results

The measurements were carried out over 3 days to assure the producibility of the data. Before starting the dosing of the tracer-gas, the background level was measured at various locations. With a known background concentration, it is possible to get an overview of the dispersion of the tracer-gas, and, therefore, the spreading of pollutants from the diesel trains. In order to quantify the amount of air provided by the ventilation system, the tracer-gas method was used. This method is superior to more common and less precise methods, such as using a pitot tupe or measuring the air velocity in the duct. The tracer-gas Freon 134a is dosed at a constant concentration. This concentration is measured both upstream and downstream of the dosing point. When measuring downstream, one must ensure that the tracer-gas is mixed optimally in the air. In this case, the dosing was done before the fan and the concentration was measured after the fan. The volume flow is calculated as shown below.

$$Qv = D/(C1 - C0)$$

where:
Qv is the volume flow in m^3/s
C1 is the concentration downstream
C0 is the concentration upstream
D is the dosage rate in mg/s

The airflow, based on the tracer-gas measurements, turned out to be some 30% lower than that based on the air velocity measurements. During the ventilation measurements, the Multipoint Sampler and Doser 1303 was set-up to dose Freon 134a at a rate of 77mg/s, which ensured a sufficiently high concentration, around 100-500 ppb, in the vicinity of the ventilation outlet.

Fig.5 shows measurement results from both the platform in question and the results from different locations in the subway system. A mobile Photoacoustic Multi-gas Monitor 1312 carried out these measurements. The reason for using two separate systems was due to the distance between the stationary dosing system and the sampling points. Furthermore, having too much tubing on the heavily trafficked platform was not permitted due to safety reasons. It can be seen that both the CO and Freon 134a levels are significantly lower away from the platform and the ventilation system in question.

Fig.4 The mobile Photoacoustic Multi-gas Monitor 1312 in the Metro section of the subway system

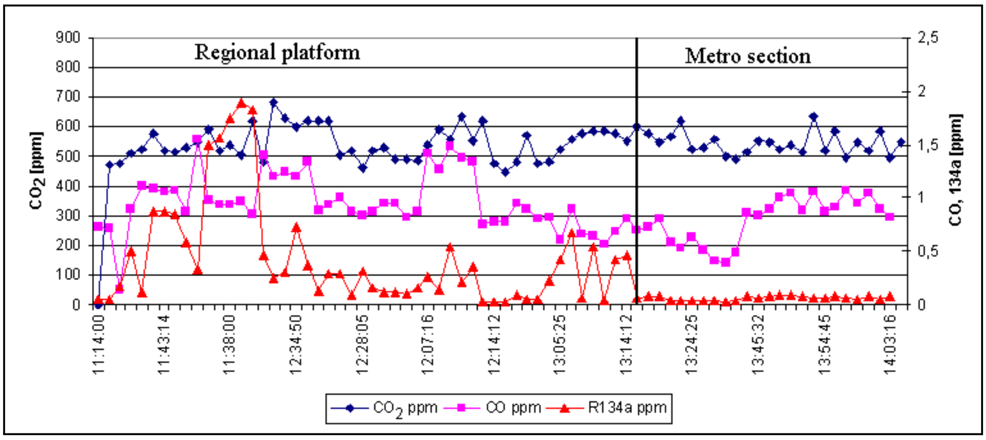

Fig.5 The results measured by the ventilation monitoring system as displayed by the Application Software 7620

INNOVA
AirTech Instruments

Innova AirTech Instruments A/S
Energivej 30,
DK-2750 Ballerup, Denmark

Tel.: (+45) 44 20 01 00
Fax: (+45) 44 20 01 01

www.innova.dk
E-mail: innova@innova.dk

Innova AirTech Instruments has 45 international agents and distributors. For further information about our products or the name of your local contact, please call +45 44 20 01 00, or visit our homepage on the Internet at www.innova.dk.

BO 0508–11