Adjustment of the ventilation in a Complex tunnel System

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ABSTRACT

The complex tunnel system in Tromsø, consisting of three main tunnels and three roundabouts, a parking area, shorter connecting tunnels, all inside the mountain has difficulties with achieving acceptable air quality.

Due advanced monitoring and new software wit a large number off possibilities to parameterize the ventilation an attempt to achieve better conditions have been made.

One on the main result is that a correlation found in one tunnel, is near to worthless in other tunnels.

keywords: tunnel ventilation; correlation between dust and CO

1 INTRODUCTION

The tunnel complex in Tromsø is a complex system consisting of three tunnels and an underground parking area. All connected by three roundabouts, and a short connecting tunnel, inside the mountain. Se figure 1 for principal connections.

Tunnel segment Breivika has concrete surface, the other segments have asphalt.

This causes an increased amount of airborne dust in this segment.

During an upgrade of software and communication in the tunnel system it was installed dust monitors in segment Breivika and Sentrumstangenten. We also set the number of steps for the ventilation to 11.

2 RESULTS

Due to demands from the local fire brigade, who has one entry wherever a fire will start, all air has one entry, and is then spread throughout the tunnel complex.

During normal operation the ventilation start in accordance with pollution. Figure 2 show where the pollution is measured. Table 1 give what is measured.

The changes in ventilation had two goals.

1) Improvement of air quality

2) Reduction of bill for electricity.

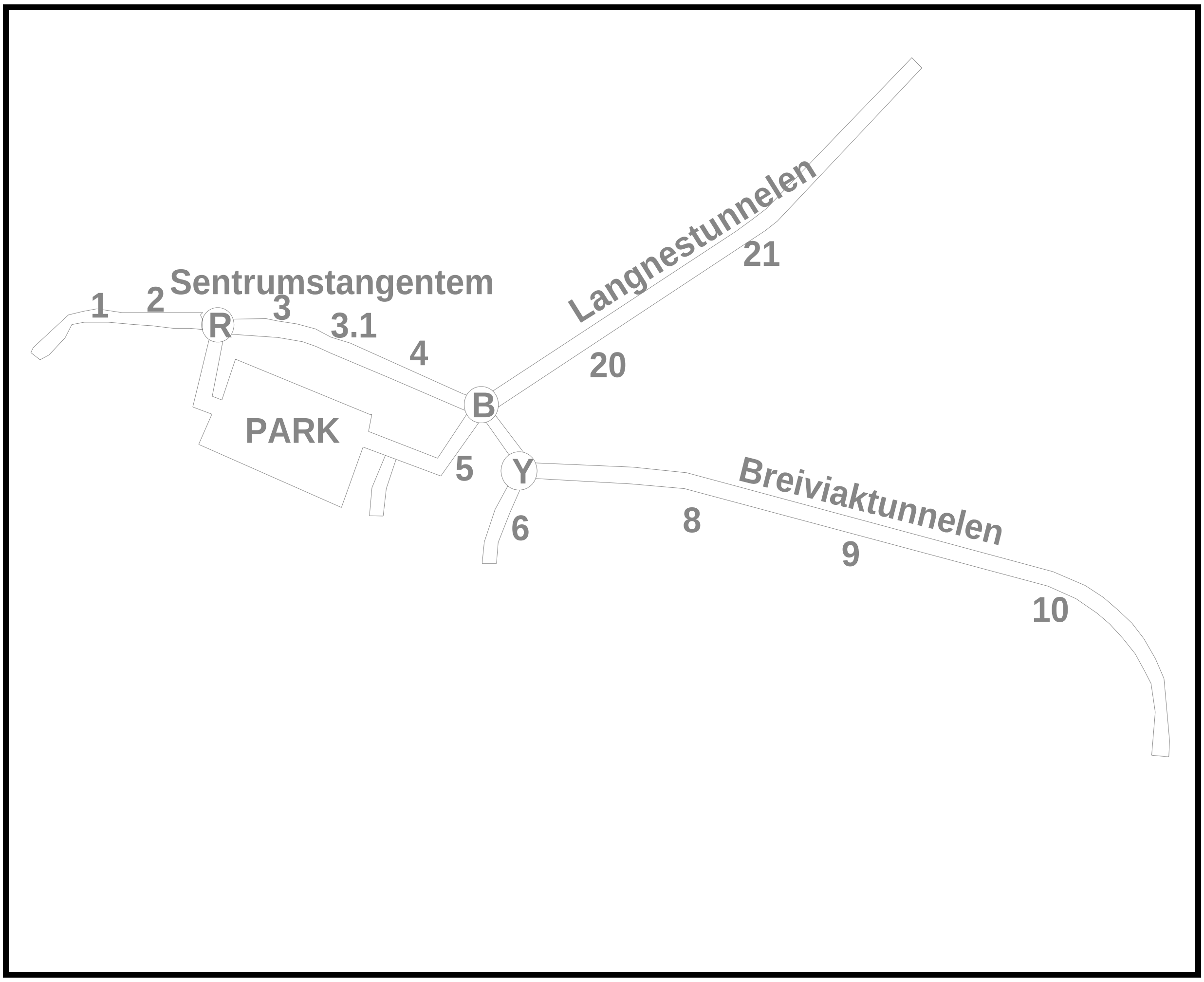
These goals are in opposition to each other.

Experience from the Bømlafjord tunnel [1,2] indicated that this should be easily achieved. And the first preliminary results indicated that it would be so. But as winter was going on, without any possibility to clean the tunnels, conditions was getting worse.

(It is not wise to use water when the temperature is well below freezing point.)

Originally the pollution had only been able to start the ventilation in three steps.
With the new possibilities we has 11 steps to tune, and parameterizes.

Without the benefit of flow measurement in the system, we have to ensure that the number of fans started in every segment results in the desired direction of flow.
This would of course have been easier if we had several flow monitors.
Ultrasonic, time of flight flow monitors are expensive, and it is difficult to convince tunnel owner to by these, without proof of cost saving for ventilation. (Any kind of point measurement for flow inside a bidirectional road traffic tunnel is worthless [3])



Figur 1

The numbers shown in Figure 1 gives approximately placement of measuring stations.
The letters R, B and C indicates Red, Blue and Yellow roundabout inside the mountains.
Each of the main tunnels is bidirectional, with traffic on approximately 8000 to 11000 vehicles a day.
Length of tunnels:
Langnestunnelen 1800m.
Sentrumstangenten: 1600m
Breivikatunnelen: 2500m

Table 1 Measuring stations				
1	CO	NO_2		
2	CO	NO_2	Rh	Dust
3	CO	NO_2		
3.1			Rh	Dust
4	CO	NO_2		
5	CO	NO_2		
6	CO	NO_2		
8	CO	NO_2		
9	CO	NO_2	Rh	Dust
10	CO	NO_2	Rh	Dust
20	CO	NO_2		
21	CO	NO_2		

Table 2 Number of fans activated in the different sections, by different steps

Step	Sentrums tangenten	Park From middle of Sentrumstangenten to Parking	Between B and Y	Langnes	From Y to exit	For y Breivika
Step 1	1	1	1	3	2	1
Step 2	3	1	2	3	2	3
Step 3	4	1	2	3	2	7
Step 4	4	1	2	3	2	8
Step 5	7	1	3	5	4	9
Step 6	10	1	2	2	4	8
Step 7	8	1	2	6	4	6
Step 8	8	2	3	4	4	12
Step 9	10	2	2	4	4	12
Step 10	10	2	3	11	8	12
Step 11	29	3	4	11	8	22

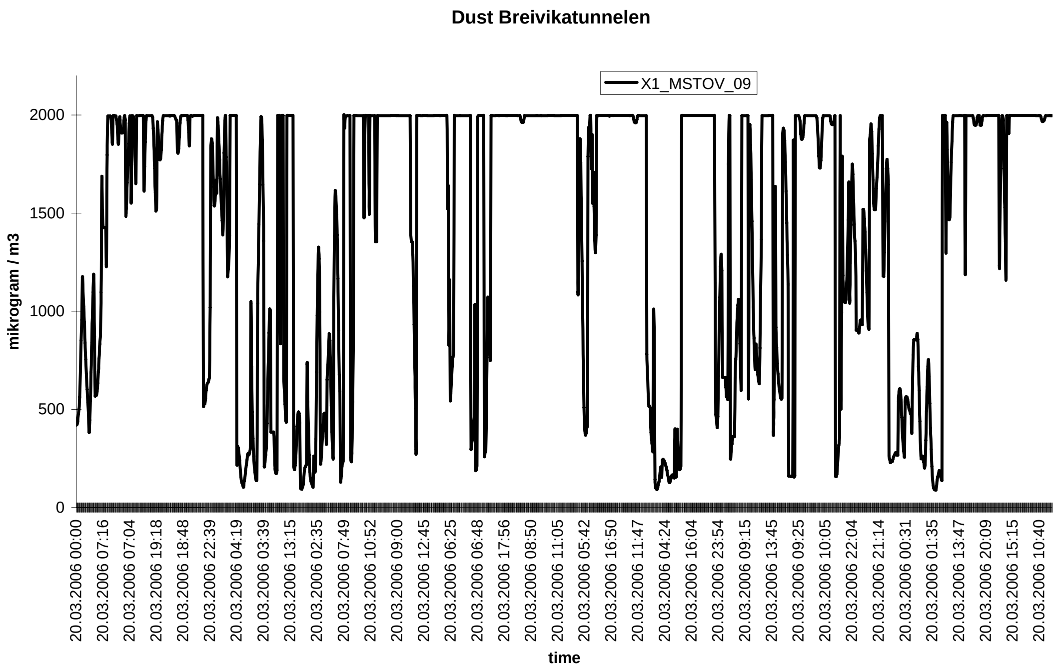
By changing the number of fans, started in each segment in different steps, we have 11 scenarios for ventilation.

For each measuring device as a dust monitor, CO monitor etc we has the possibility to set 11 different start criteria and average time for the measurement. Average time has been 300 seconds for all measurements. Calculation of average is done by first PLS reading the instrument. We are saving all data to a log each minute.

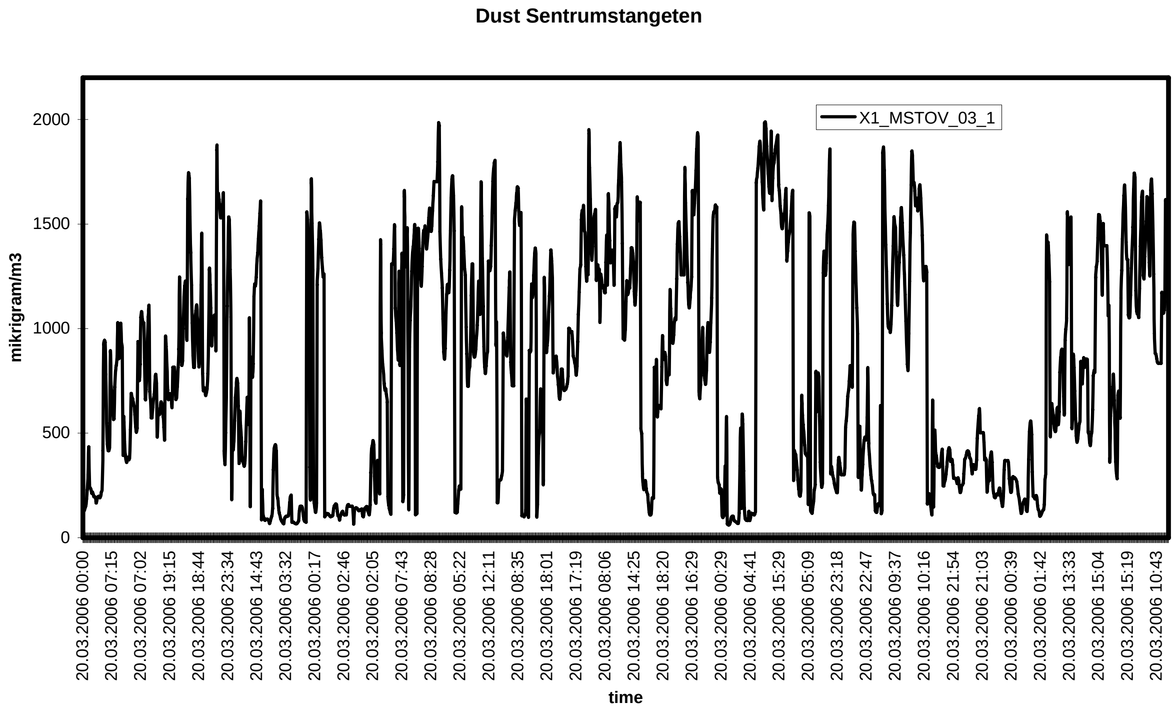
During the first months of logging we had indications that showed a reduction in effect compared to the previous year.
With actual settings this was later on showed to be wrong. When the situation is that the measuring limit of the dust measurement is exceeded most of time, we got a problem. The measuring area of the instrument will be increased later this year.

Due to extended analysis of the use of ventilation, at what caused the start of the ventilation we have changed the setting for start.

This is done by logging start criteria, and pollution values over time, and then analyzing this.



Figur 2 Dust measurement one day in the Breivikatunnel



Figur 3 Dust measurement in the Sentrumstangenten tunnel for one day

Unfortunately the only information available from earlier years are kWh used, and that the pollution in the tunnels has been not acceptable, concerning dust.

Experience from the Bømlafjordtunnel showed that acceptable dust levels could easily be achieved, by starting ventilation after dust levels. But in the Bømlafjordtunnel main dust component is soot, not concrete dust. It is no problem to ventilate out soot. Concrete dust is larger particles, and not easily ventilated. This was well known. Because of this they regularly use MgCl salt as dust binder in the tunnels. The effect of MgCl salting, shows imminently in the airborne dust levels. But this is only visible for a few days, with the existing settings for dust measurements. These settings, in the dust monitors will soon be changed.

One of the other results, is that a correlation between $NO/NO_2/CO$ and dust in one tunnel is nearly worthless in an other tunnel.

Where we in the Bømlafjordtunne could find a correlation between CO and dust, NO and dust, we see that in these tunnels we will have a very different correlation between dust and CO Where the correlation for the

Bømlafjordtunnel is $\text{Dust} = 8{,}5301 \cdot CO_{(ppm)} + 72{,}983$

we have for the Breivika tunnel $\text{Dust} = 37{,}186 \cdot CO_{(ppm)} + 127{,}1$

These values are a quick calculation for one day only. For both tunnels you will individually have a correlation on approximately 0.75.

So be aware, **results from one tunnel can not be used in other tunnels,** without testing, when you are considering correlations between dust and CO and dust and NO_2.

These differences are also visible in the results. When optimizing the Bømlafjordtunnel, we had a reduced cost of electricity, and improved conditions in the tunnel. In the complex system I Tromsø, we have according to the public improved garrulity, but at a high cost.

We are by today not satisfied with the results, and will do some more changes to the system.

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