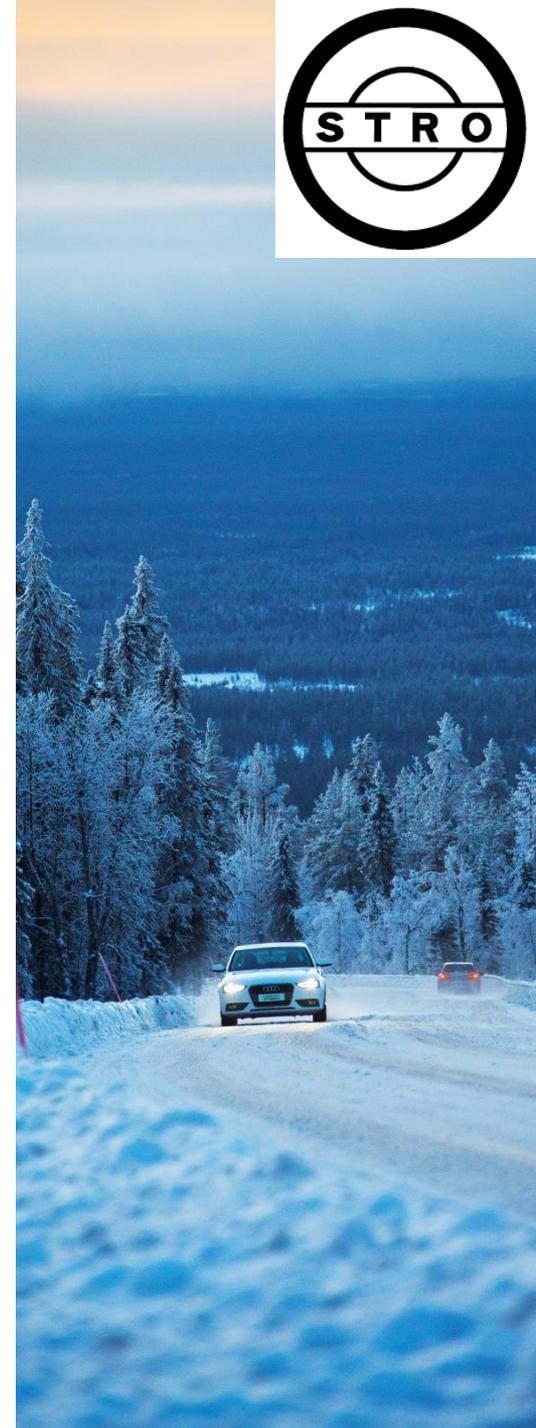


# **STRO Studded Tyre Expert Group (STEG) comments on VTI Study:**

**Emission of inhalable particles from studded  
tyre wear of road pavements  
- a comparative study of premium studded tyres**

**EDEN Meeting Oslo  
25.9.2015**

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# VTI study:

"Emission of inhalable particles from studded tyre wear of road pavements - a comparative study of premium studded tyres"



## Introduction

- STRO welcomes the opportunity to comment on the VTI study "Emission of inhalable particles from studded tyre wear of road pavements - a comparative study of premium studded tyres"
- Some findings or aspects of the study are surprising because they differ from assumptions based on previous measurements or engineering judgment. Before drawing conclusions on the results and relating them to real life conditions, the following issues need to be studied:
  - Work cycle of the tyre in the Carousel machine
  - Road wear phenomena caused by the studs, share of two components, grinding and impact wear
  - Impact of stud protrusion and other design parameters, like stud shape, as well as the environmental conditions
  - Estimation of implications for air quality/ Applicability of NORTRIP Model

# VTI study:

"Emission of inhalable particles from studded tyre wear of road pavements - a comparative study of premium studded tyres"

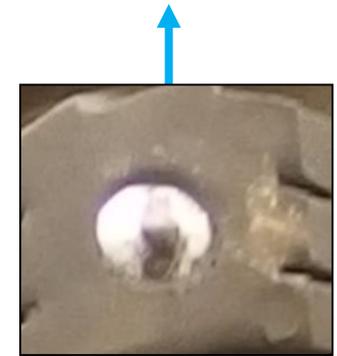
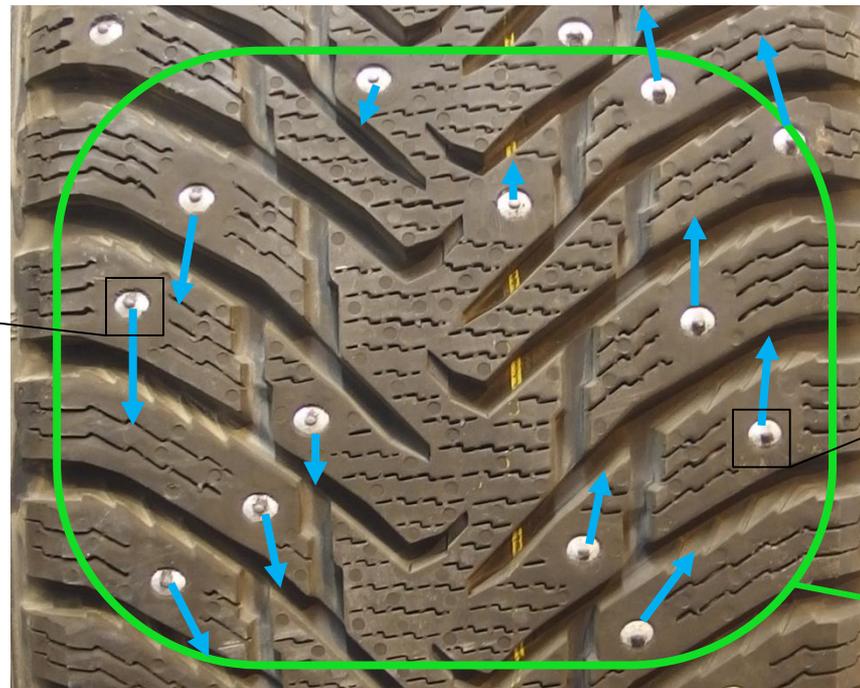


## Carousel machine and turn slip

- At the carousel machine, the tyres are under heavy turn slip, which differs from the real life work cycle of tyres, also causing an extraordinarily high sliding of studs
- The studs on different shoulders of the tyre slide on the opposite directions. This can be seen on the wear and bitum remains of carousel machine tested tyre studs.



Sliding direction



Estimated footprint area



# VTI study:

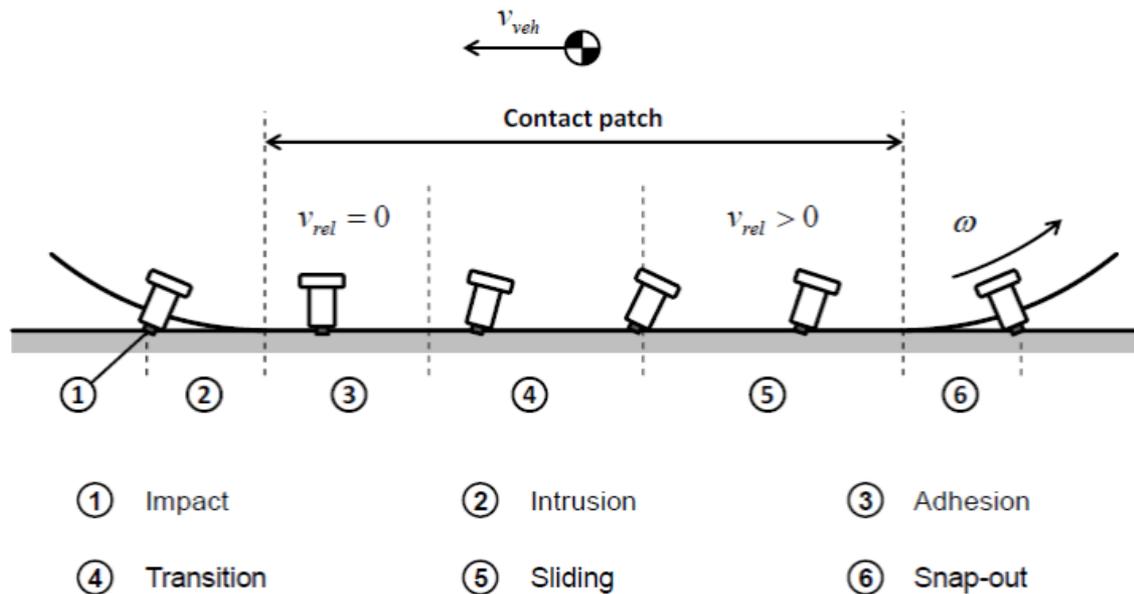
"Emission of inhalable particles from studded tyre wear of road pavements - a comparative study of premium studded tyres"



## Road wear mechanism

- In other words, VTI carousel machine is magnifying step 5 "Sliding" compared to free rolling situation in real life and the step 1 "Impact" is playing a minor role.

Stud-track interaction in the contact patch (traction forces)



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## Particle size distribution

- The particle size distribution generated by various tyres was studied – according to the study: "The mean percentage of PM<sub>2.5</sub> of PM<sub>10</sub> was 24 % with no obvious differences between the tyres."

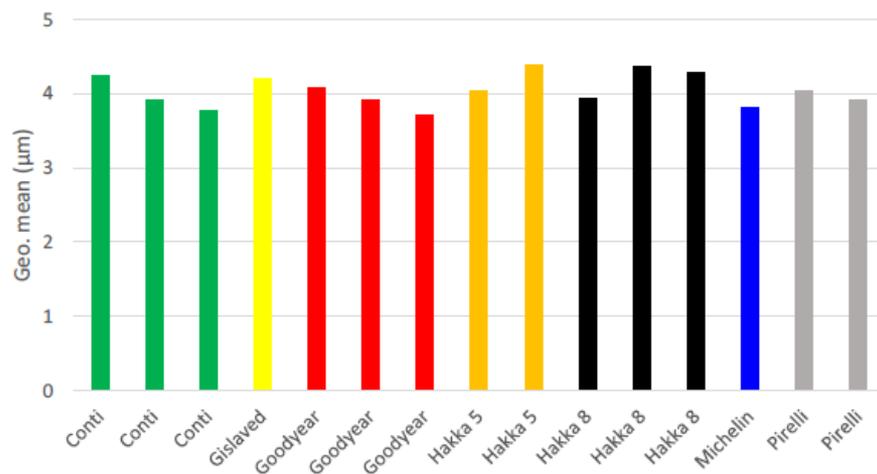


Figure 9 Geometric mean size of particles analyzed using the APS instrument.

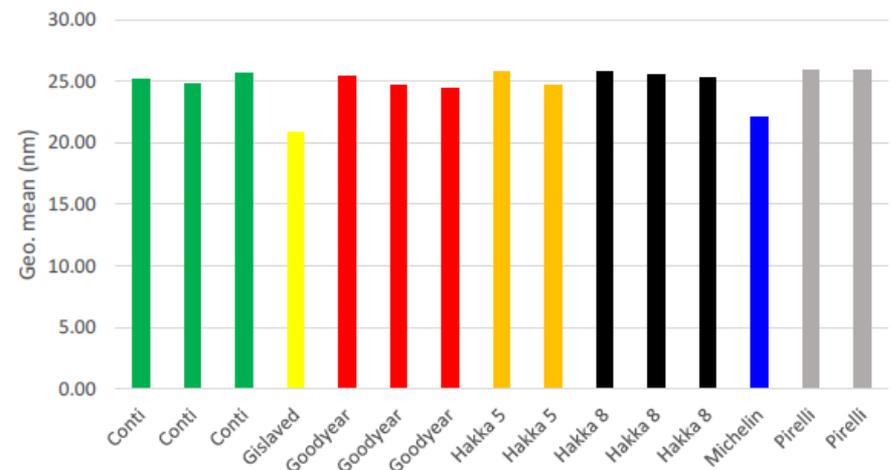


Figure 14 Geometric mean size of ultrafine particles analyzed using the SMPS system.



# VTI study:

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## Further investigation of stud parameter influence, e.g stud protrusion

- Table of different parameters effecting the PM10 emission

Some of the parameters influencing PM10 emission and road wear	Taken into account at analysis of VTI study	Influence to road wear and PM-emissions	
		According the analysis of VTI study	Engineering assumptions
Stud weight	No	-	High
Stud pin shape	No	-	High
Stud body shape	No	-	Medium
Stud protrusion	Yes	Medium	High
Number of studs	Yes	High	Medium
Statical Press in force of stud	Yes	Medium	Medium
Under tread layer compound temperature behaviour	No	-	High
Tread compound hardness	Yes	Medium	Medium
Tread pattern	No	-	Medium
Structural stiffness (against turn slip)	No	-	High
Environmental parameters			
Road temperature	Yes	High	Medium
Air temperature	Yes	High	Low
Humidity	Yes	High	Low
Tyre temperature	Yes	High	High
Speed	Yes	High	High
Road surface wet/dry	No	-	High
Natural temperature range	No	-	High
Real road driving speeds	No	-	High
Driving forces: acceleration, deceleration, steering	No	-	High

The most significant parameters according VTI analysis

# VTI study:

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## NORTRIP Model and Estimation of implications for air quality

- NORTRIP model is a simulation tool for analyzing the effect of weather and traffic conditions and the maintenance actions to the local PM concentration.
- The PM10 emission of studded tyres is not the only parameter influencing the exceedance days, but one of the factors beside the traction sanding, meteorological conditions, combustion and wood burning exhaust and long-range depositions, maintenance and dust binding.

### Model concept and processes

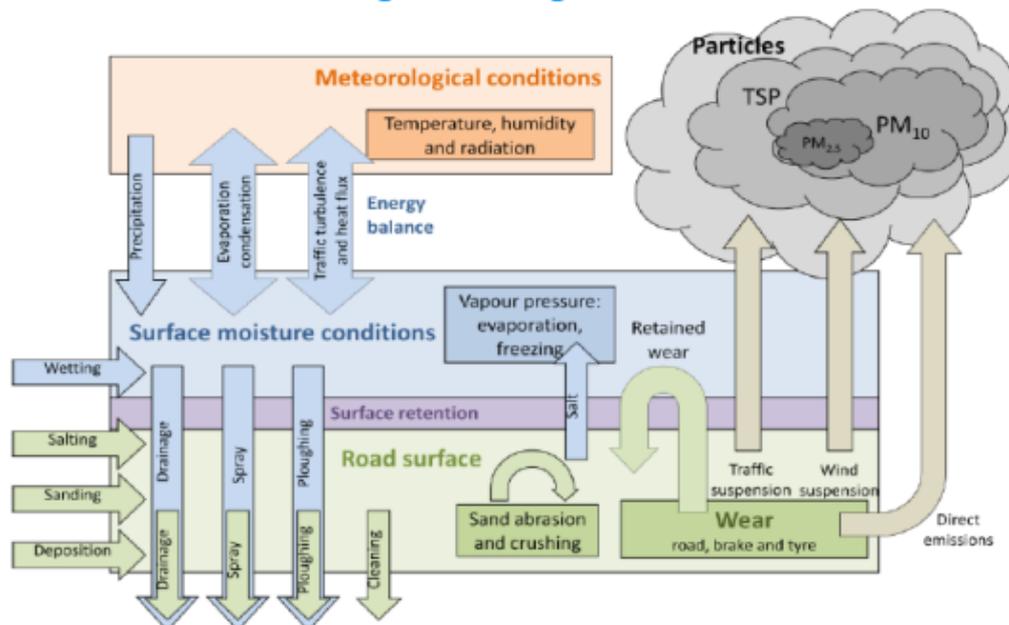


Figure 1.1. Schematic outline of the NORTRIP emission model.

Source: NORTRIP model development and documentation  
NO<sub>x</sub> Road Traffic Induced Particle emission modelling  
Bruce Rolstad Denby and Ingrid Sundvor

# VTI study:

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## NORTRIP Model and Estimation of implications for air quality

- Studded tyre wear estimation of the NORTRIP model is based on study of Jacobson and Wågberg, 2007, where they found a correlation functions from Carousel machine wear to road wear measurements.
  - It is not clear if the correlation is based on the variety of different tyres and loads, varying the speed and environmental conditions as at actual road, as the road is usually wet on the period of usage of studded tyres.
  - The wear model used is not verified with the modern studded tyres.
  - To establish a direct correlation between real life road wear and Carousel machine pavement wear, a study including field tests and laboratory tests with large number of parameters, including various tyre and stud embodiments, stud shapes, tread hardness and environmental variables, like temperature, humidity or speed would be necessary. The tyre industry is available for any technical discussion.

### Model concept and processes

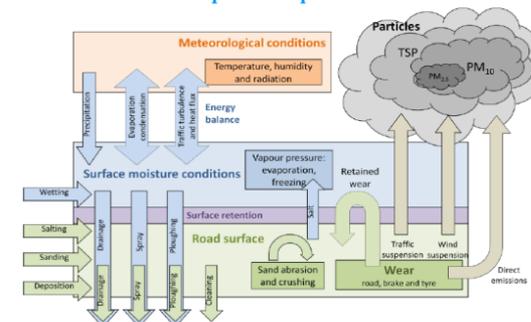


Figure 1.1. Schematic outline of the NORTRIP emission model.

# VTI study:

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## Estimation of Implications for air quality/ Applicability of NORTRIP Model

- The test of two tyres are not comprehensive enough for bringing the results to real life comparison
  - The reference value might be worse than the studied tyres
  - Only two individual tyres and tests were taken into account
  - The wear caused by the tyres is not the only mechanism generating the PM-emissions, so there is more complicated relation to exceedance days

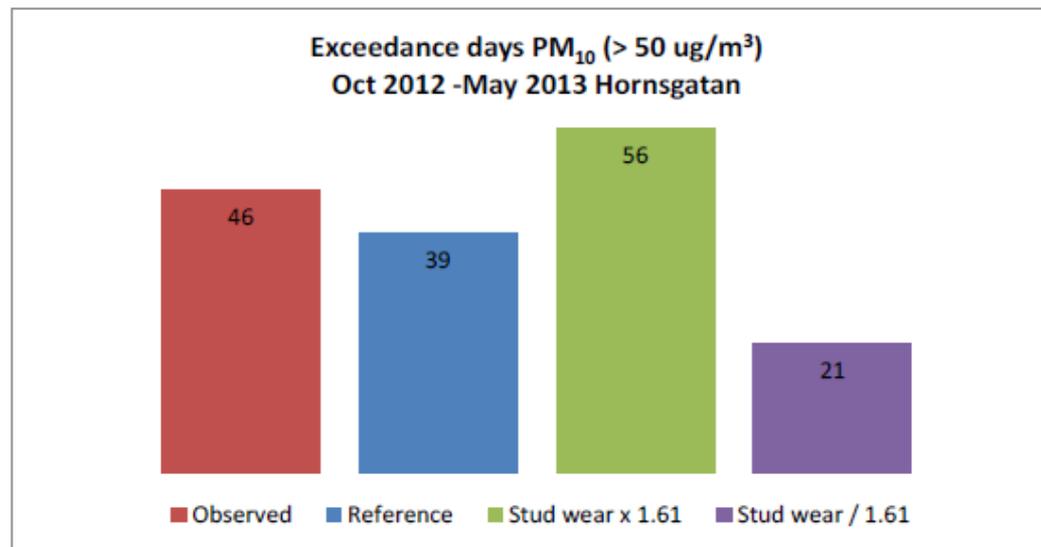


Figure 18 Effects on mean net and total  $PM_{10}$  as well as on limit value exceedance days on Hornsgatan, Stockholm of 1.6 times span of the reference wear (see text for explanation).

# VTI study:

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## Conclusions of STRO Studded Tyre Expert Group

- The work cycle of the tyre at the carousel machine is not representing actual real life tyre rolling situation:
  - Carousel over magnifies the sliding and underestimates the impact component of the studs due the heavy turn slip and the results are not directly comparable to real life traffic situation.
  - The pavement at the test was dry, when in the real life winter tyre usage period, the roads are usually not dry.
  
- Applicability of NORTRIP Model seems questionable:
  - The wear model is not taking into account the various studded tyre and condition variables
  - The extrapolation of the exceedance days when using PM10 emission of carousel test as an input is premature to draw conclusions based on the small data set of this VTI study
  
- The most effecting design parameters according the study were the hardness of the tread and the number of studs. Anyway the environmental variables, like temperature of air and tyres seemed to have more influence in the statistical analysis.
  - There are tens of parameters influencing the PM-emissions and road wear, like the stud pin shape, stud weight, under tread compounds, the tyre structural stiffness on vertical axis, for example.

# VTI study:

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## Further discussion

- Comparing the overrun test results with different conditions and tyre individuals to PM-emissions measured at VTI Carousel machine could cause misleading conclusions.
- The study highlights some important tyre design parameters affecting to PM-particle emission at carousel test. The industry has committed to investigate this in further. ETRMA has made a test campaign of the correlation of the PM10 emission and pavement wear at Carousel machine with tyre samples of various stud amounts.



**Thank you!**





# VTI study:

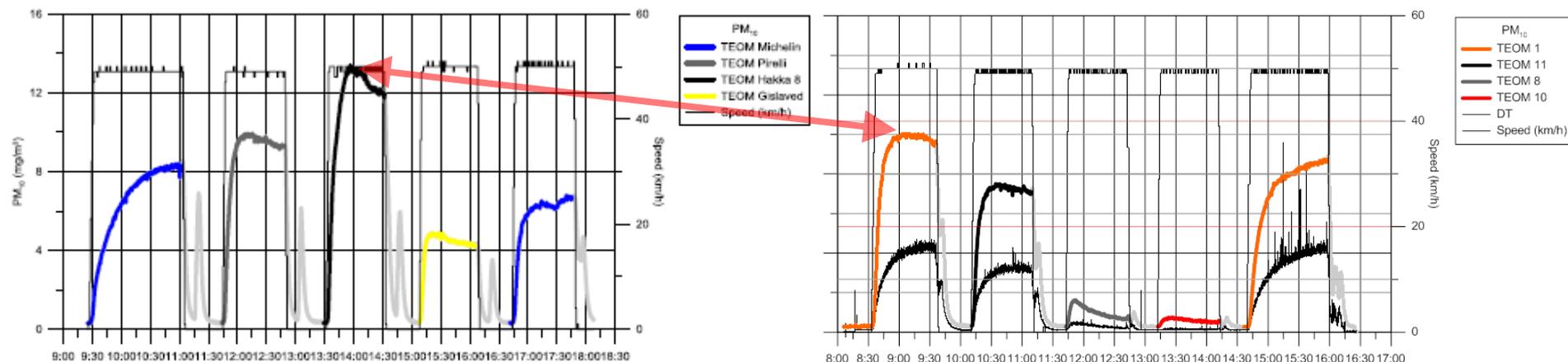
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## Quantification of PM10 and repeatability of the test

- According to Nokian Tyres tests made by VTI 2014, the results of Hakkapeliitta 8 compared to Vegvesen test 2014, the PM10 level also shows a difference of approximately  $2 \mu\text{g}/\text{m}^3$  (TEOM 1 is reference HKPL 8)
- Both tests were done with the same tyre size and same test surface (Nokian tests done after Vegvesen tests) and the same test specifications were used, but running-in and tyre individuals were different
  - The axes are fitted to the same scale

Appendix C PM<sub>10</sub> results during test days

Day 1 2014-11-20



VTI: Vegvesen and Traffikverket 2014, Hakkapeliitta 8 is black

VTI: Nokian Tyres tests 2014, Hakkapeliitta 8 is orange