SPENS Final Seminar

Ljubljana, 27 August 2009

Guidelines for the environmental assessment of various pavement types including recommendations to road authorities in New Member States

WP5 leader

Dipl.-Ing. Manfred Haider (AIT, Austria)

Overview

1. Introduction
2. Air pollution
3. Noise emission
4. Conclusions and recommendations

Part 1
INTRODUCTION

Work package 5

Impact assessment of roads on the environment

Partners: arsenal (Austria, leader), ZAG (Slovenia), VTI (Sweden), CDV (Czech Republic), TUZA (Slovakia)

Task 5.1: **Environmental assessment of pavements (global)**

Task 5.2: **Role of the road network as source of noise emissions**

Work package 5

Task 5.1: Environmental assessment of pavements

Objective:

Characterization of pavements with regard to their environmental impact to arrive at recommendations for NMS authorities

Focus properties:

Particle emission

Noise generation

Work package 5

Task 5.2: Role of the road network as source of noise emissions

Objective:

Characterization of the influence of different road pavements on the traffic noise situation and determination the potential of pavements to reduce traffic noise at the source

The basic idea is to roughly follow the SILVIA methodology (SPB & CPX) for acoustic pavement characterization. This will enable road authorities to use low noise pavements as noise abatement tool.

Work package 5

Final output:

Deliverable D17:

Guidelines for the environmental assessment of various pavement types including recommendations to road authorities in NMS

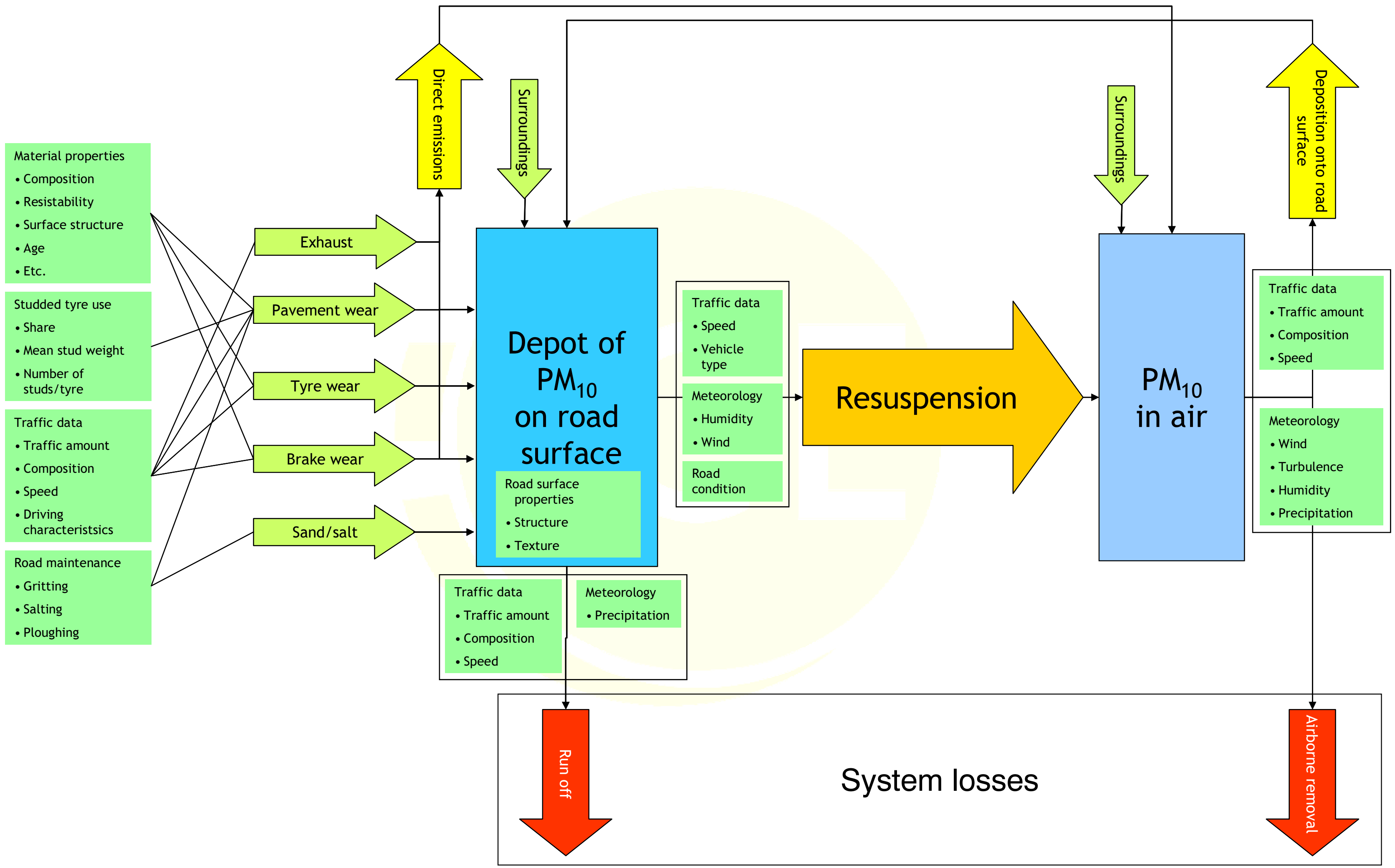
Part 2
AIR POLLUTION

Particle measurements at the VTI road simulator

Mats Gustafsson & Göran Blomqvist, VTI

Anders Gudmundsson, Lund University of Technology

Background: The road dust system



Background: Road dust

- Problem with air quality standards in Norway, Sweden and Finland due to use of studded tyres + winter sanding.
- Road dust (non-exhaust particles) is also an issue in countries without studded tyres. Pavement, tyre and break wear as well as winter maintenance (sanding and salting) are important contributions.
- Road dust constitutes an increasing share of road traffic particles due to reductions of exhaust particles using filters and the absence of measures against non-exhaust particles.

Pavements under test

ACO 11 S, asphalt 50/70 Diorite

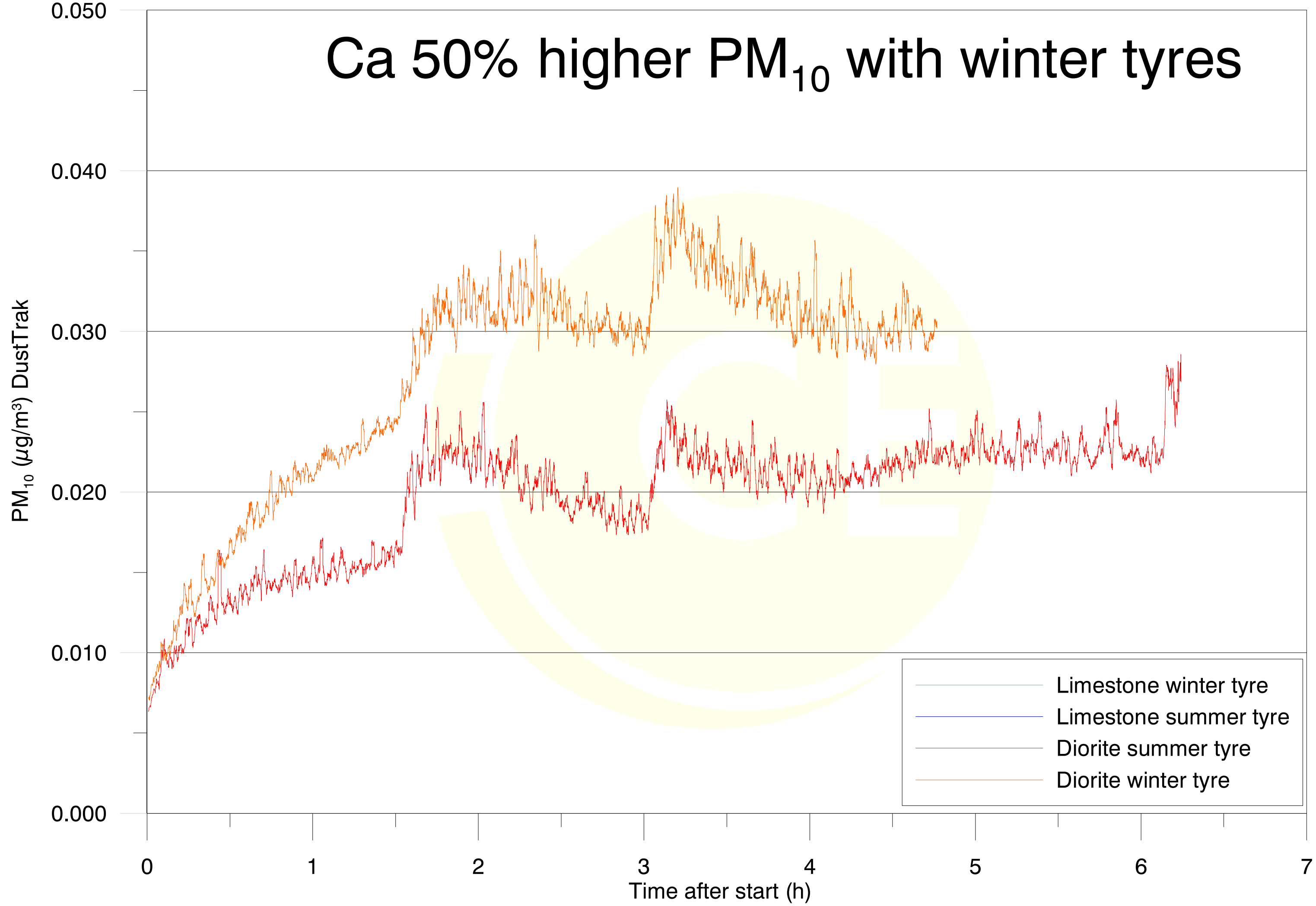
AC 11 surf, B70/100 Limestone

Test tyres

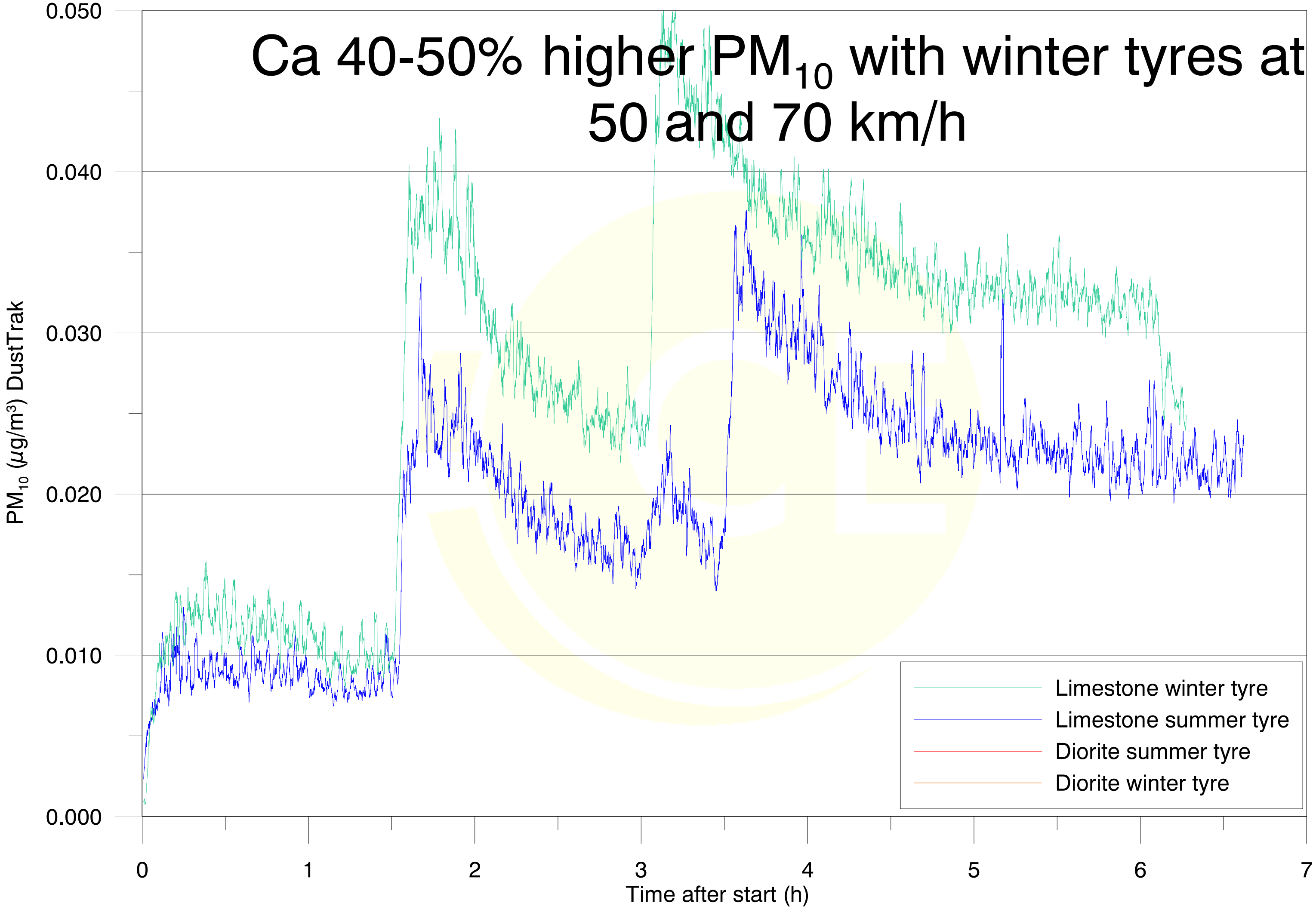

Summer tyre:
Michelin Pilot Primacy


Winter tyre:
Pirelli Sottozero

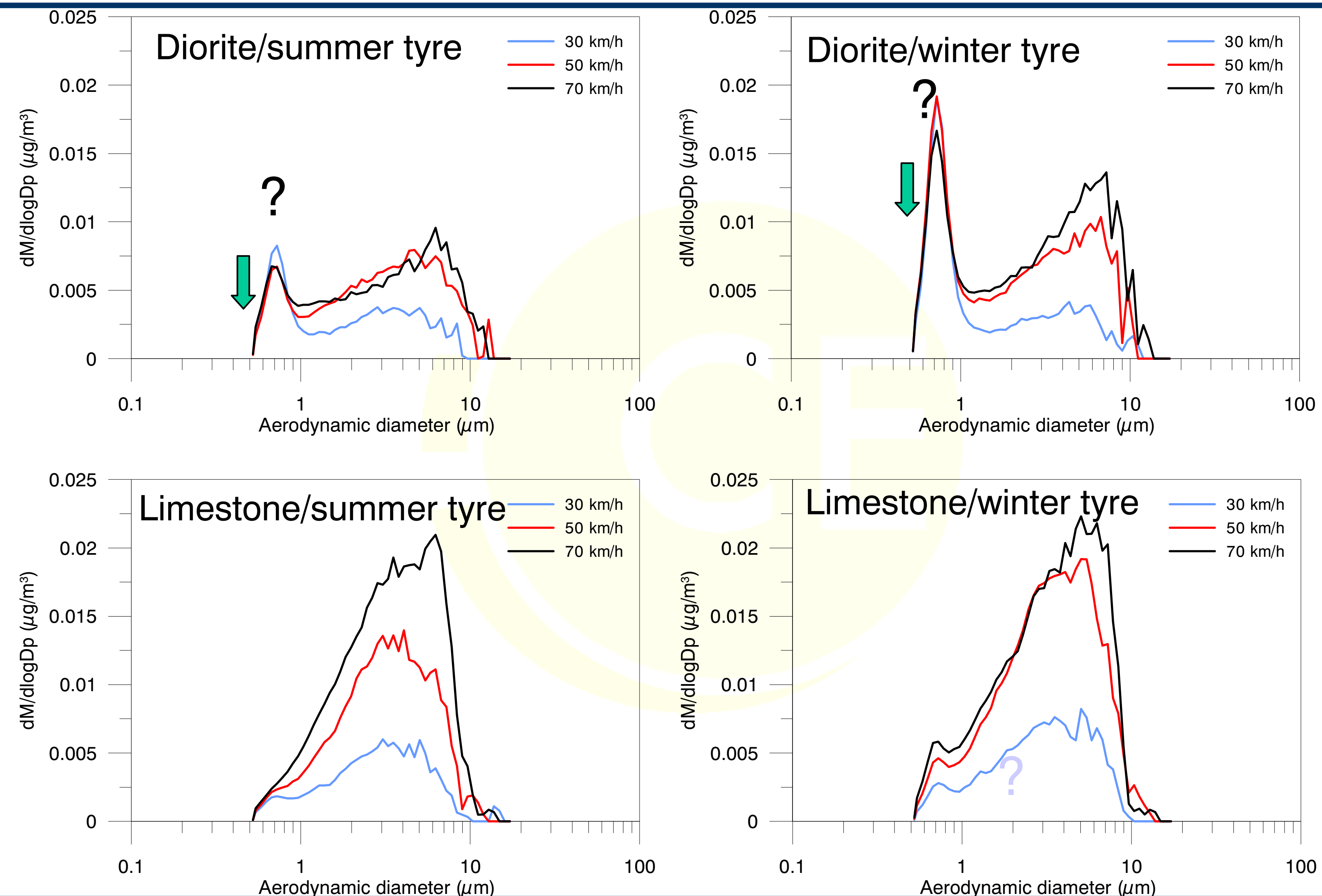
Results: both tyre types on Diorite pavement



Results: both tyre types on Limestone pavement

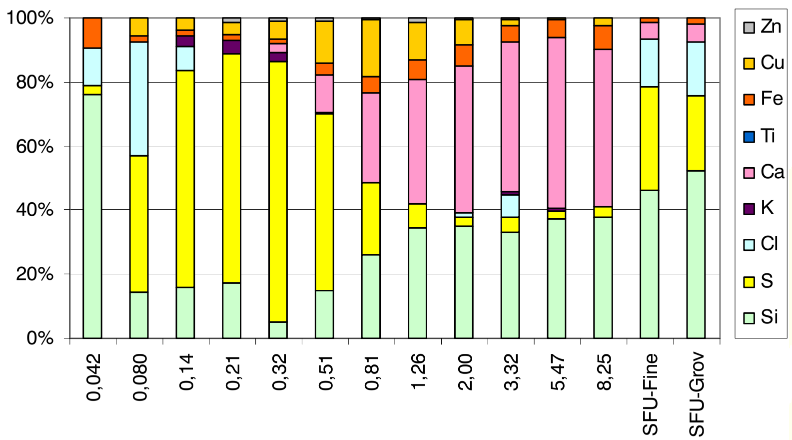


Results: mass size distributions at different speeds

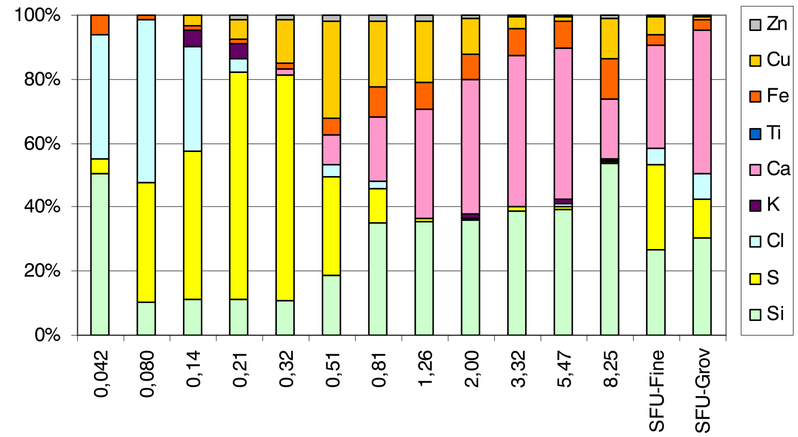


Results: elemental composition (PIXE analysis)

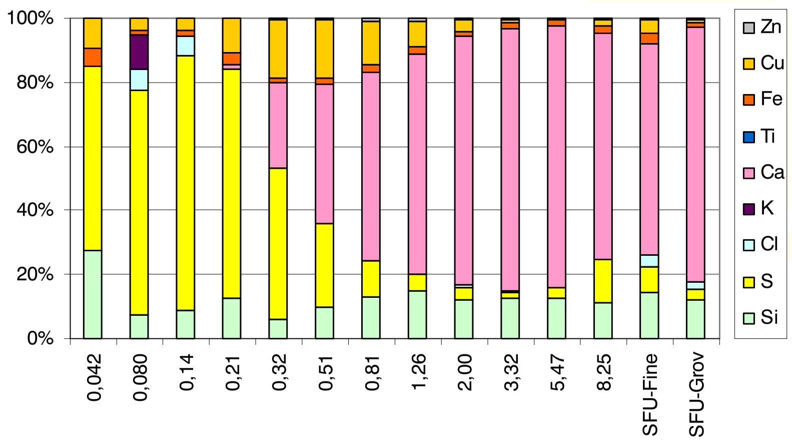
Diorite/summer tyre



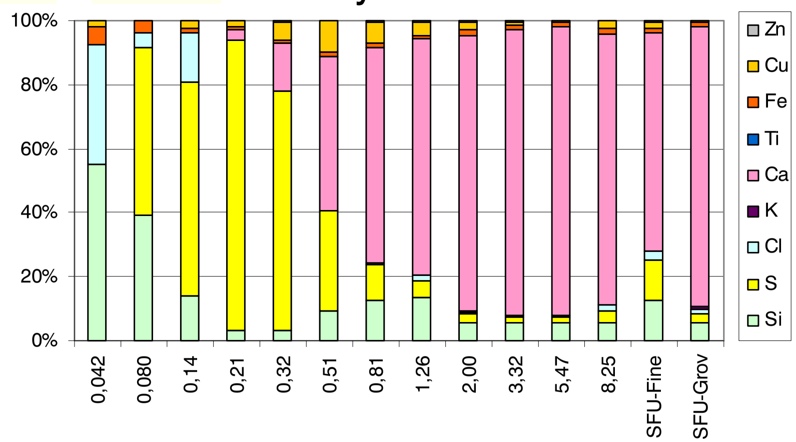
Diorite/winter tyre



Limestone/summer tyre



Limestone/winter tyre



Conclusions from the VTI experiments

- Inhalable particles (PM_{10}) are emitted from tyre wear of both pavements and the levels are similar as for tested Nordic pavements.
- The softer limestone pavement emits slightly more PM_{10} than the diorite pavement
- The winter tyres generate ca 40-50 % higher PM_{10} emissions than the summer tyres
- The fraction above 1 μm is dominated by mineral particles from the pavements
- The size fraction below 1 μm is dominated by sulphur originating in tyres or bitumen

Recommendations

- Pavements contribute, through tyre wear, to airborne inhalable particle concentrations and the properties of the pavement affect the amount, physical and chemical properties of the dust formed.
- In road and street environments where the EU PM_{10} limit values are exceeded, the contribution from pavement wear should be investigated
- If pavement wear particles are found to be an important source, pavements can be adjusted through using other stone material and constructions.

CDV and TUZA activities

- Particulate matter (PM) concentrations measurements in cooperation with Technical university in Žilina
- Dust fall measurements in road tunnels in Prague
- Preparation of the most abundant pavement type samples in the Czech Republic and Slovakia

PM concentrations measurements

- Localities with different pavement

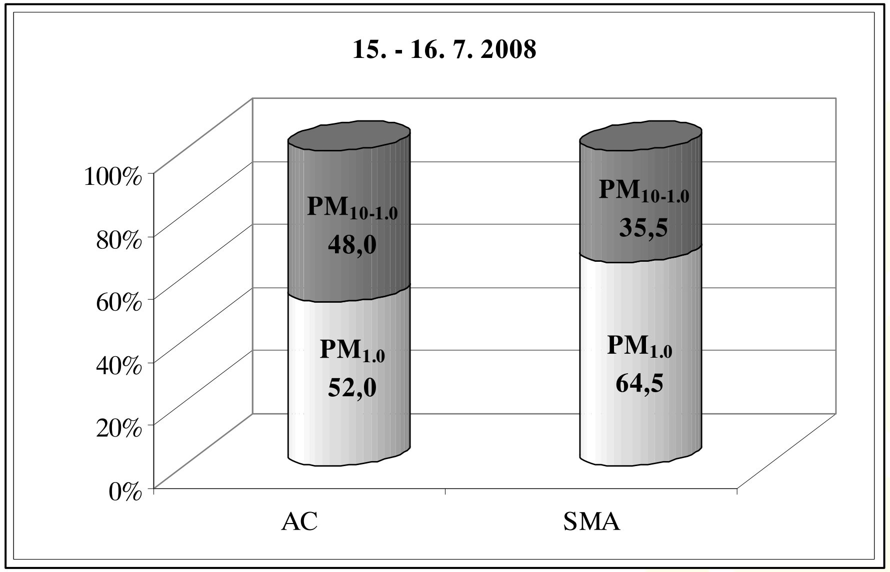
  highway D1 – stone mastic asphalt
  town circuit – asphalt concrete

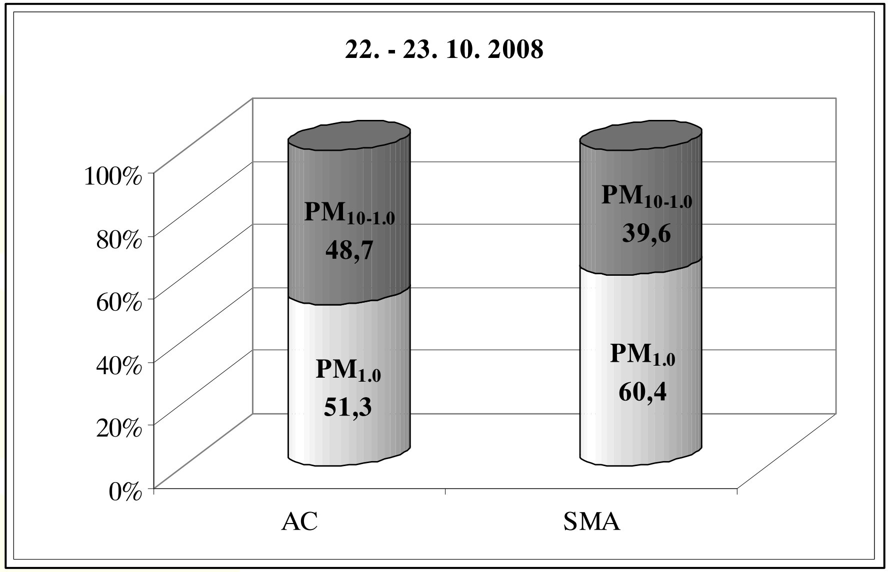
- Samplers LECKEL MVS 6 (6pc.), different kinds of filters

- Two measuring campaigns

  July and October 2008

PM concentrations measurements





- PM_{10} concentrations - higher on the locality with AC pavement
- The share of coarse fraction – higher on the locality with AC pavement

Dust fall measurements in tunnels

Strahovský tunnel (cement concrete pavement) and Mrázovka tunnel (asphalt pavement) are components of Prague town circuit with different pavements

- Sampling campaigns
- Samplers placed near the tunnel centre in each in each tube
- Selected pollutants content determination
- Quantification of dust sources using statistical methods (PMF, PCA)

Conclusions from the CDV and TUZA experiments

- PM_{10} concentrations - higher on the locality with AC pavement
- $PM_{1.0}$ fraction - dominant on locality next to highway with SMA pavement
- Content of selected elements in both PM fractions was higher on locality with AC pavement
- Higher amount of the dust fall in tunnel with cement concrete pavement
- Higher amount of the dust fall in downward-sloping tubes

Part 3
NOISE EMISSION

Activities in the SPENS project

Analysis of statistical data on road pavements being used in the European New Member States

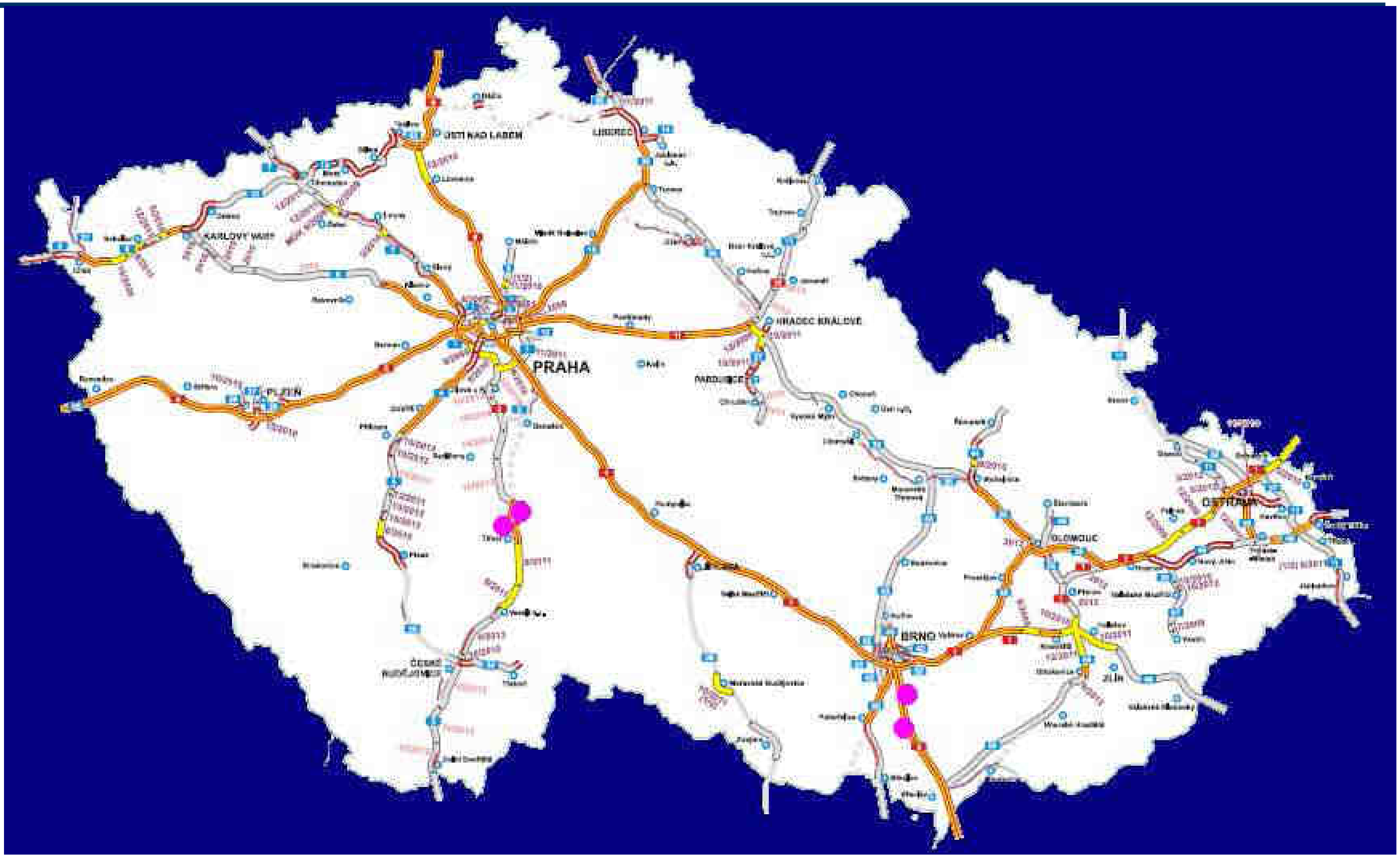
Measurements of acoustic parameters of selected road surfaces using the SPB method (Statistical Pass-By method) and the Close-proximity method (CPX) in Slovenia, Slovakia and the Czech Republic

Findings on the influence of road surfaces on traffic noise and formulation of recommendations

Overview of the noise emission measurements

- Measurements in Slovenia, Slovakia and the Czech Republic
- At least 3 measuring sites per country
- SPB measurements performed by local partner (CDV, ZAG, TUZA)
- CPX measurements performed by AIT

Measuring sites in the Czech Republic



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Statistical pass-by measurements

1. position – noise measurement
2. position – speed measurement, vehicle classification

SPB example results: Cement concrete pavement (Czech site No .1)

Location of test surface:
12,6 km from Brno on motorway D2, direction to Brno, Czech Republic

Age: 1977

Posted speed limit: 130 km/h

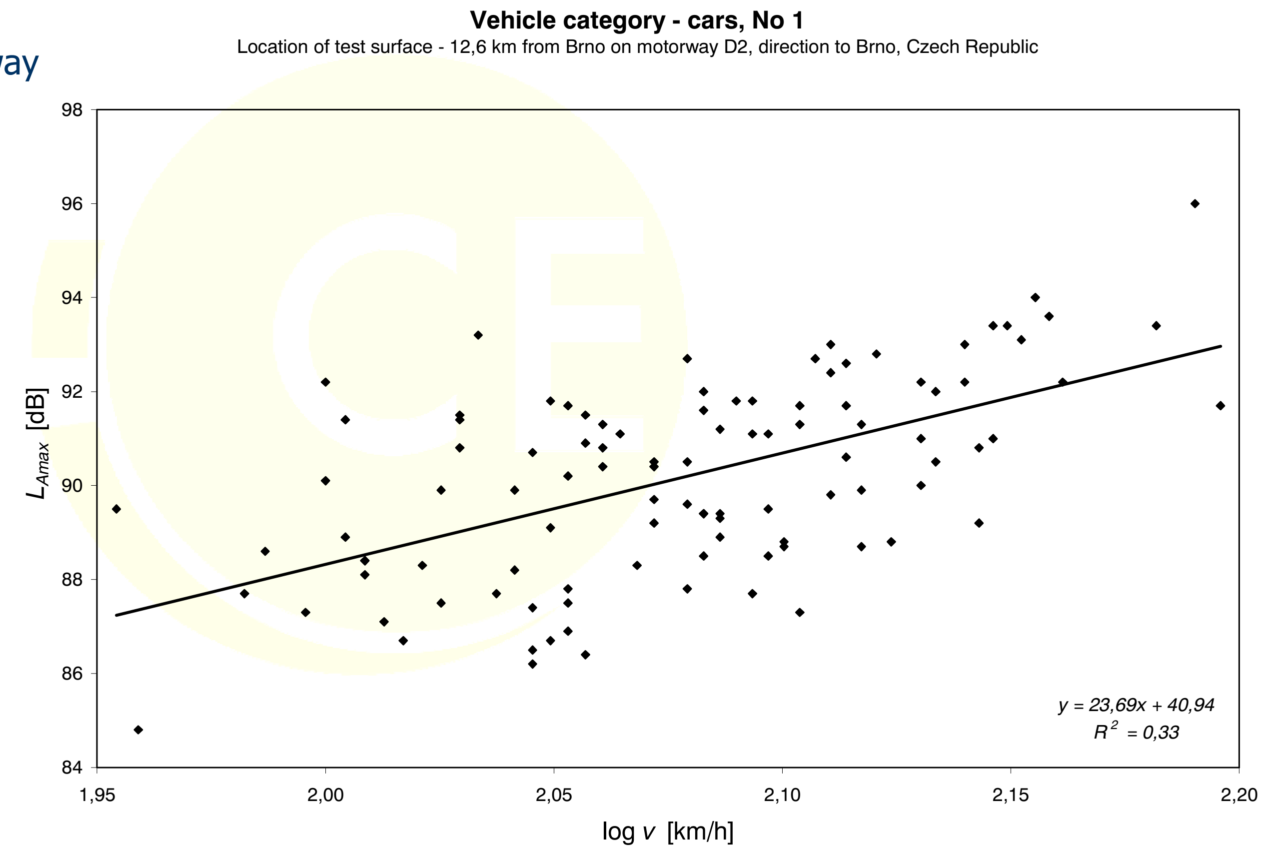
Date of measurement: 22.11.2007

Dampness: 74 %

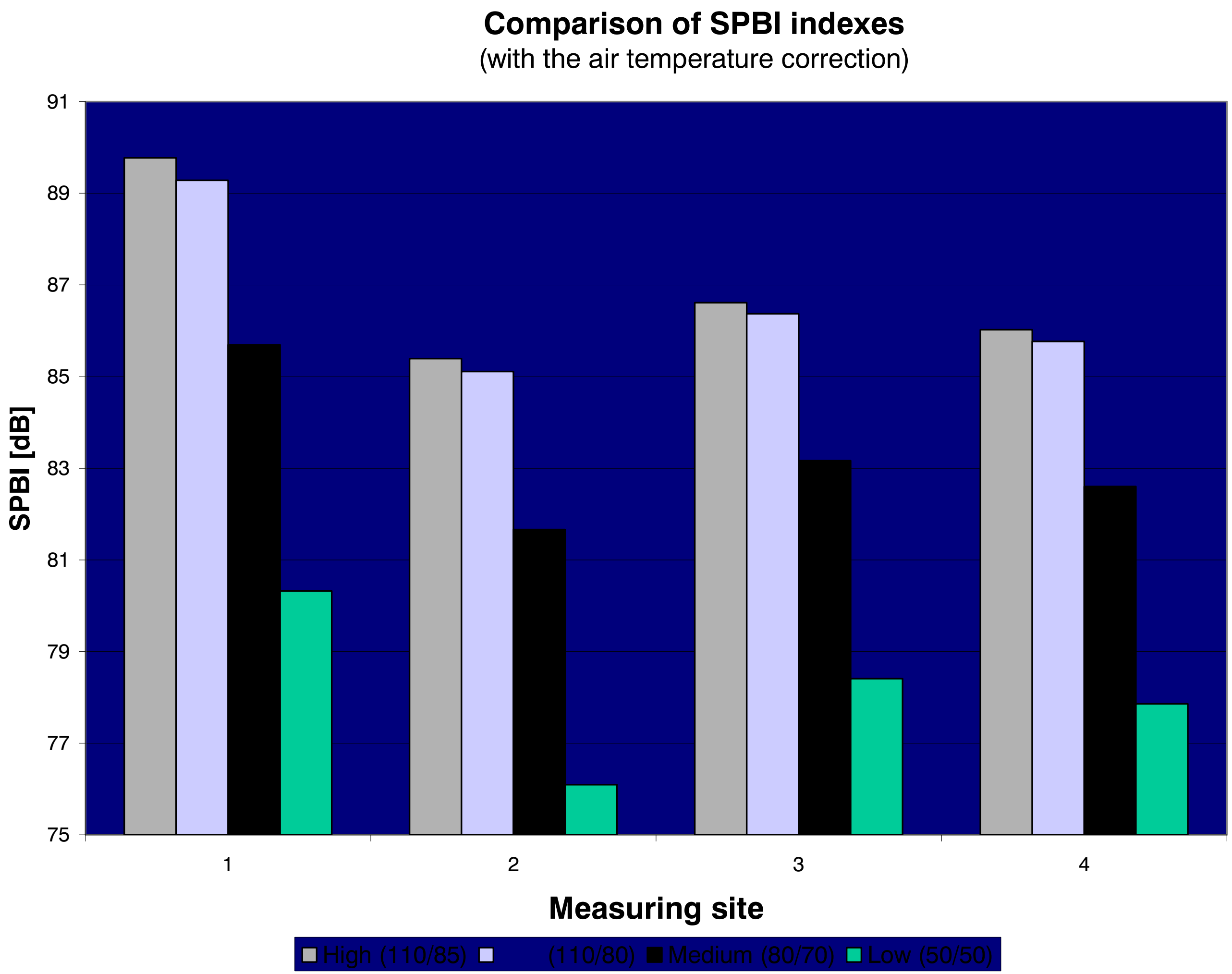
Wind speed: 3 km/h

Static pressure: 992,7 hPa

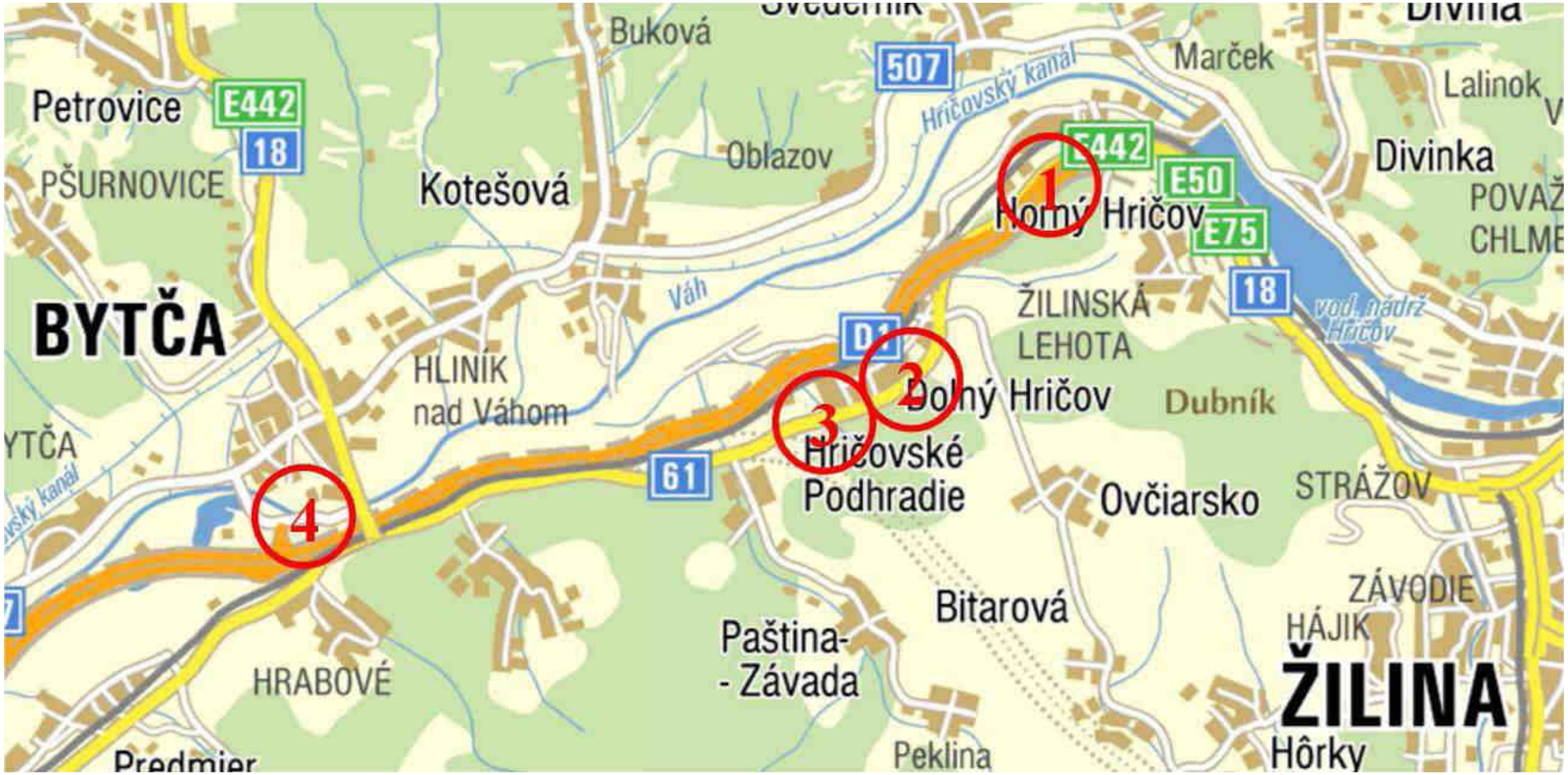
Road surface temperature during measurement: 5,6 °C



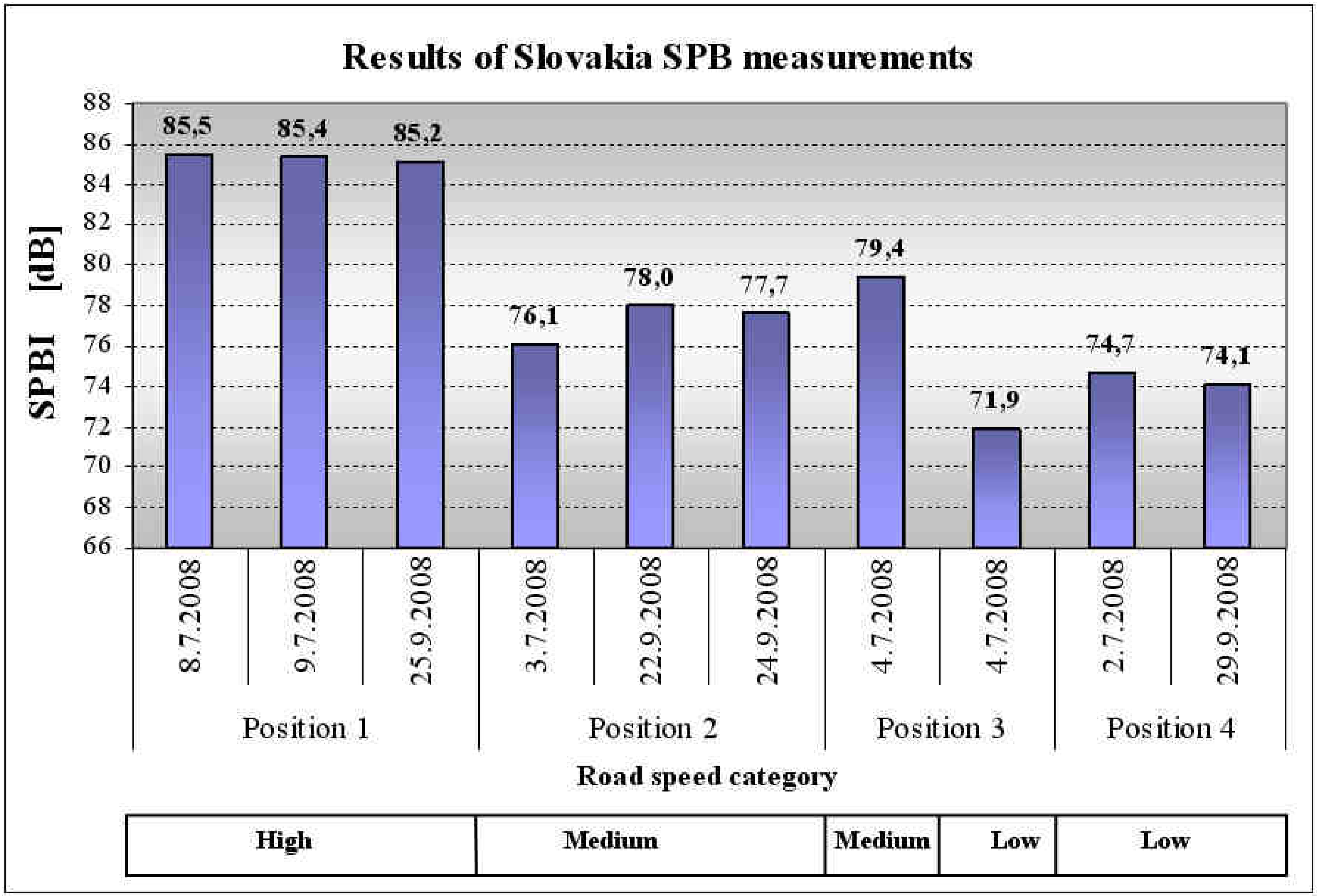
SPBI for the Czech sites



Slovakian positions for SPB and CPX measurements



Results of Slovakian SPB measurements



Position 1 - highway D1, - SMA 11 (modified asphalt) - pavement 2 years old
Position 2 - road 1st class I/18, - AC_O 11 - pavement 2 months old
Position 3 - road 1st class - AC_O 11 - 15 years old
Position 4 - road 3st class, - SMA 11 - 15 years old

Noise emission - Slovenia

Three types of pavements were found to be predominantly used in Slovenia:

Stone mastic asphalt SMA 8s,

Asphalt concrete AC 8s,

Asphalt concrete AC 11s.

They represent approximately 70% of the documented part of the road network.

Noise emission - Slovenia

SPB measurements by the road
G2 - 102/1461 Logatec

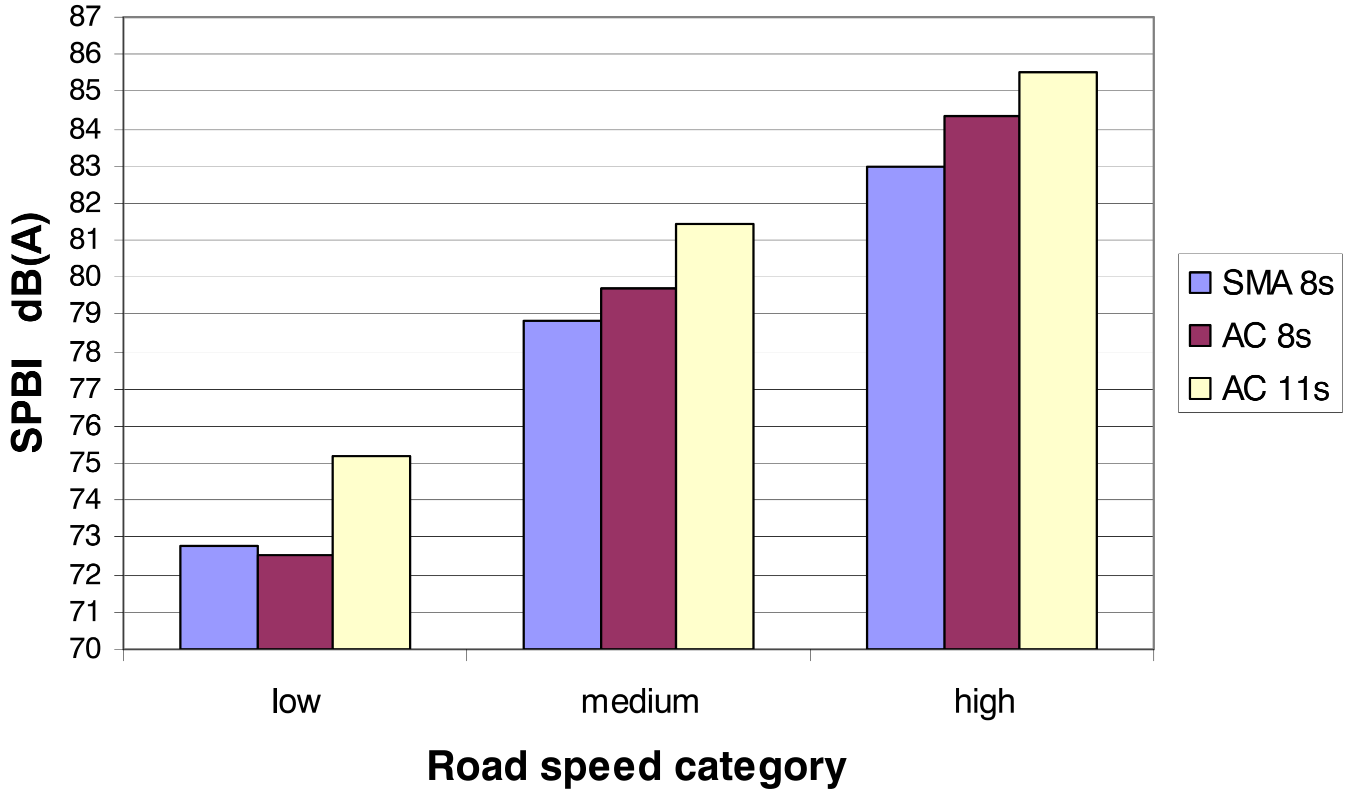
Noise emission - Slovenia

Test sites with characteristic road surfaces

Type of road surface	Age (years)	Road speed category	Road section	Denotation	Part of the road section with the specified surface
SMA 8s	8	low	Domžale - Trzin	R2 - 447/0294	km 0,656 – km 1,570
AC 8s	9	low	Logatec	G2 - 102/1461	km 0,000 – km 1,672
AC 11s	3	low	Sp. Brnik - Moste	G2 - 104/1137	km 1,000 – km 2,700

Noise emission - Slovenia

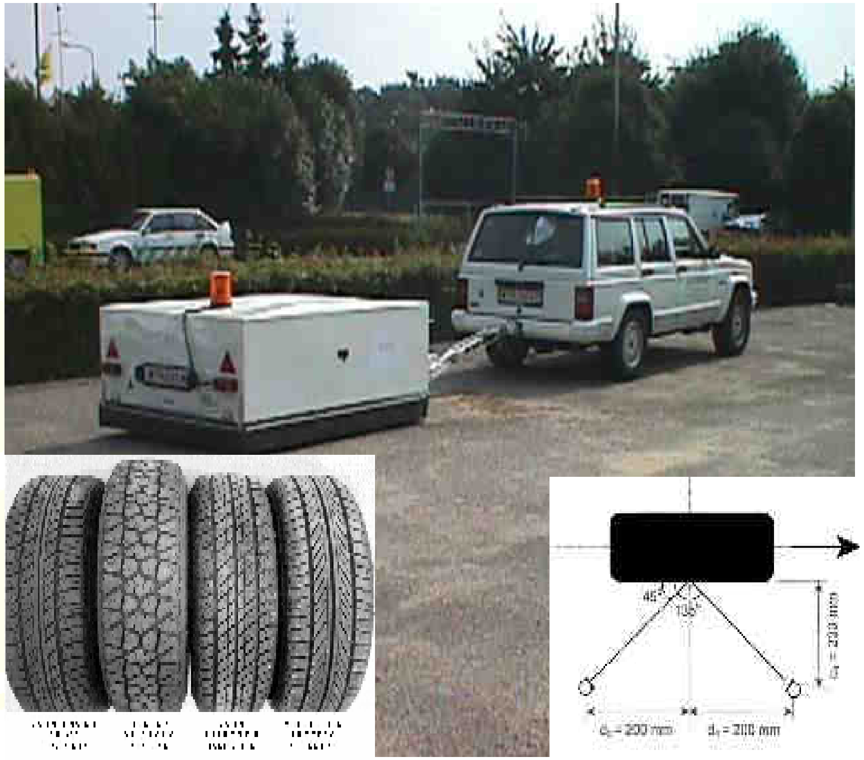
Comparison of SPBI indexes for the considered road surfaces (temperature corrections applied)



CPX measurements by AIT

Close ProXimity Method : draft standard ISO/CD 11819-2

- Trailer method → check homogeneity of noise emission properties of road surfaces over <u>long distances</u> → used for approval testing
- Four specified reference tyres: A, B, C and D → <u>survey method</u>: A for passenger cars and D for trucks
- Microphones: measure the energetic average of the A-weighted sound pressure level every 20 m
- Reference speeds: 50, 80, 110 km/h



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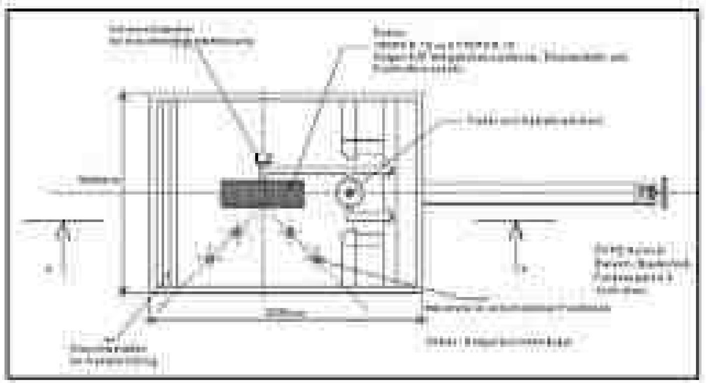
CPX Method

Advantages:

- long road sections can be measured
- background noise and reflecting objects do not affect the results
- measurements in the normal traffic flow

Disadvantages:

- engine noise is not included in the results
- propagation effects cannot be covered (microphone close to the test tyre)
- methods depends on the representativeness of the test tyres



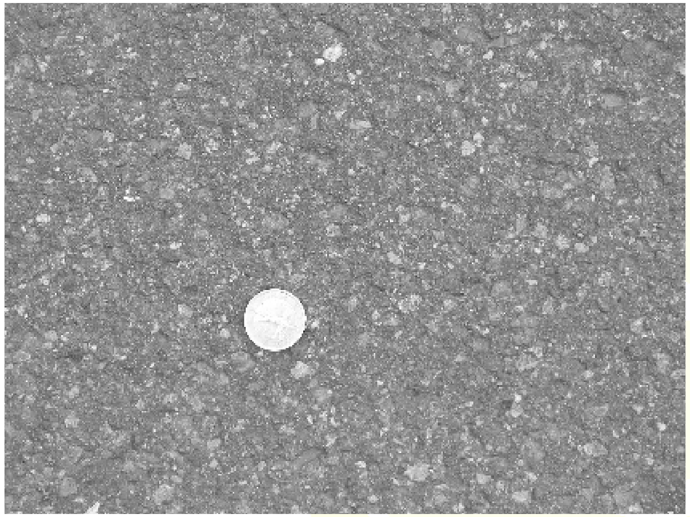
Measurement Sites

- Pavement material: CC, SMA and AC with 8 and 11 chipping size
- Pavement age: between 2 months and 15 years
- Reference speed: 50 and 80 km/h

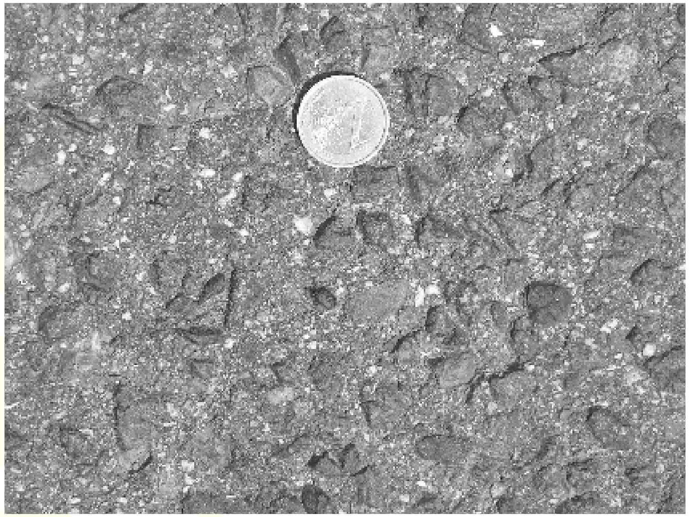
Country	Location	Pavement type	Age of the pavement	Reference speed used for CPX tests
Slovenia	Domzale	SMA8s	8 years	50 km/h
Slovenia	Lahovce - Brnik	AC11s	3 years	50 km/h
Slovenia	Logatec	AC8s	9 years	50 km/h
Slovakia	Bratislava D1	SMA11	2 years	80 km/h
Slovakia	Dolny Hricov east	AC11	2 months	50 km/h
Slovakia	Dolny Hricov west	AC11	15 years	50 km/h
Slovakia	Bytca	SMA11	4 years	50 km/h
Czech Republic	D3 to Prague	SMA11	4 years	80 km/h
Czech Republic	D3 to Ceske Budejovice	SMA11	4 years	80 km/h
Czech Republic	D2 to Brno	SMA11	12 years	80 km/h
Czech Republic	D2 to Brno	Cement concrete	31 years	80 km/h

Slovenian road surfaces

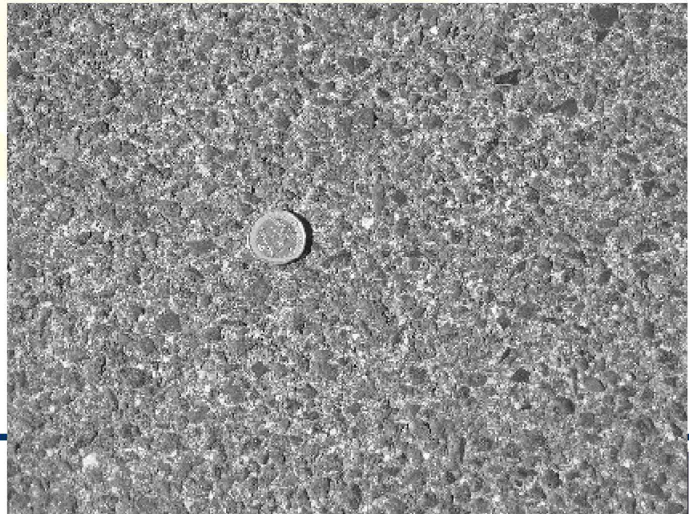
SMA8s in Domzale (8 years)



AC11s in Lahovce-Brnik (3 years)



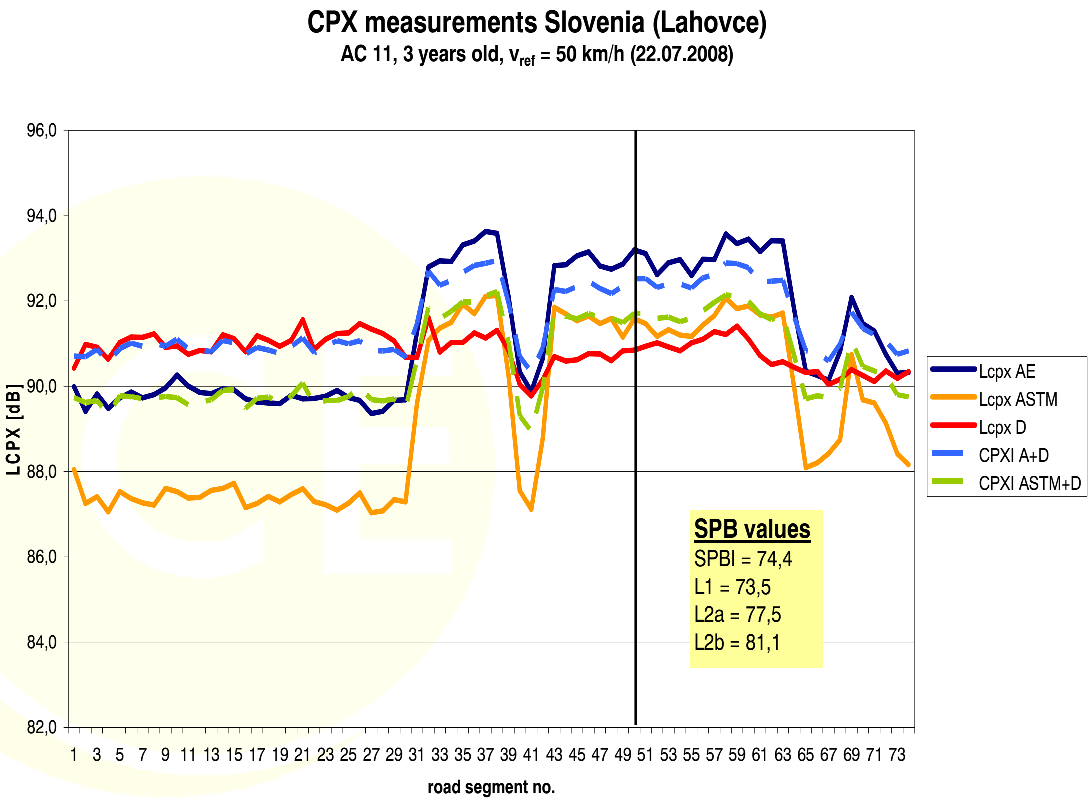
AC8s in Logatec (9 years)



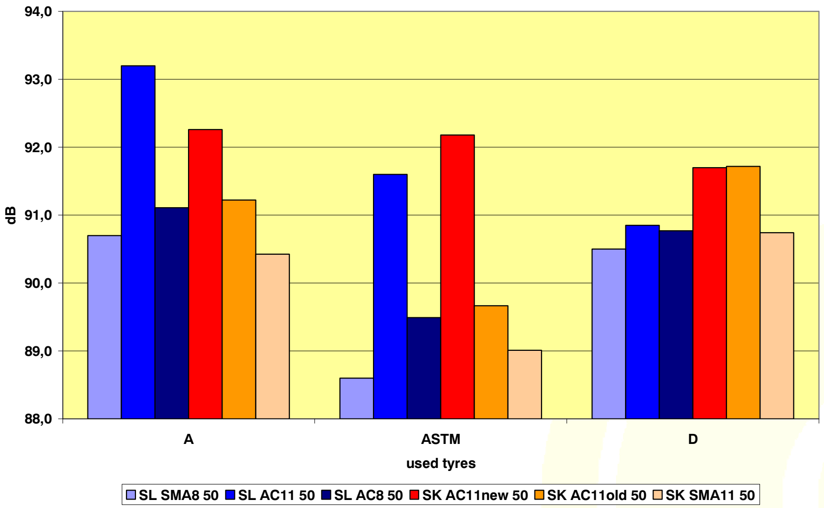
70% of the Slovenian road surfaces

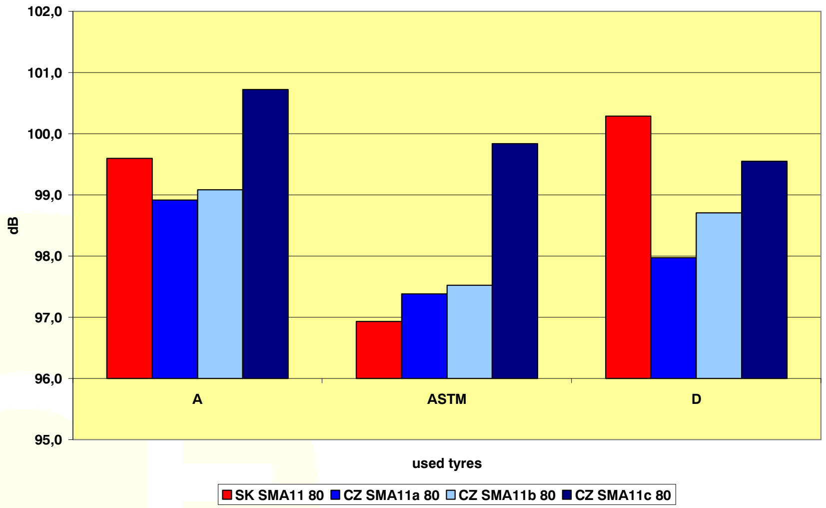
Results: Overall Analysis

- CPX results over time at Lahovce (Slovenia) for tyre (A, ASTM and D) and SPB results at the road segment no. 50
- Discontinuity in the pavements easy to identify
- A and SRTT more detailed information → tyre D: average of the sound emission of the road surfaces
- Level difference between A and ASTM SRTT tyre about 2 dB



Results: CPX Levels





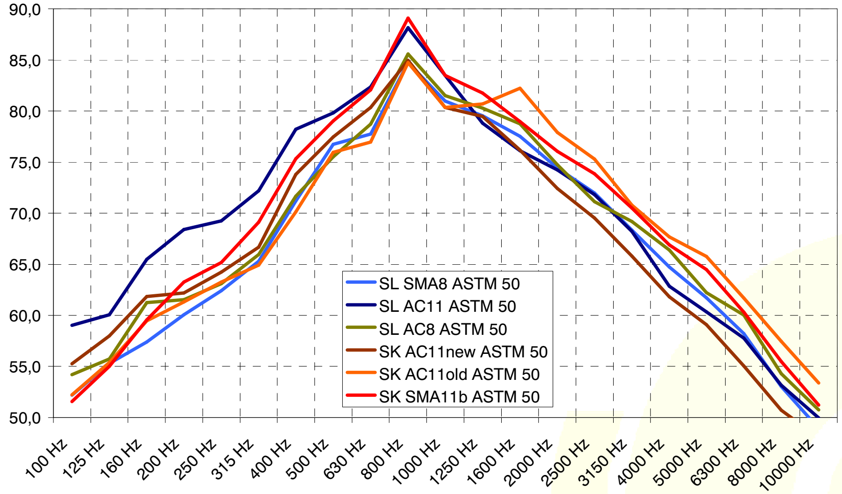
Pavement tested at 50 km/h:

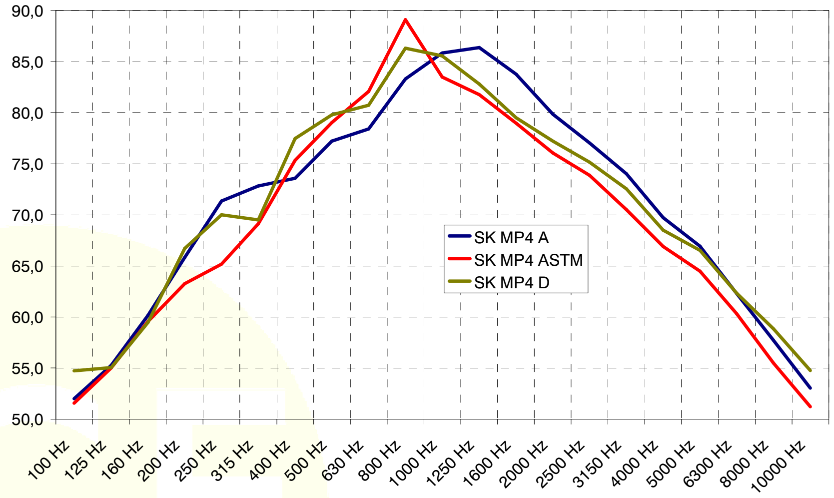
- CPX levels between 88,5 and 93,2 dB
- Span from 1.5 (tyre D) to 4 dB (for A and ASTM) → D averages surfaces because of the more gross profile
- Ranking between the pavements similar for each used tyre

Pavement tested at 80 km/h:

- CPX levels between 96,8 and 100,7 dB
- Ranking of the three SMA11 measured in Czech Republic maintains the same ranking for each tyre (same material!)
- Span between most and less noisy pavement is 2 to 3 dB for all the three tyres

Spectral Analysis





Differences within the pavement types:

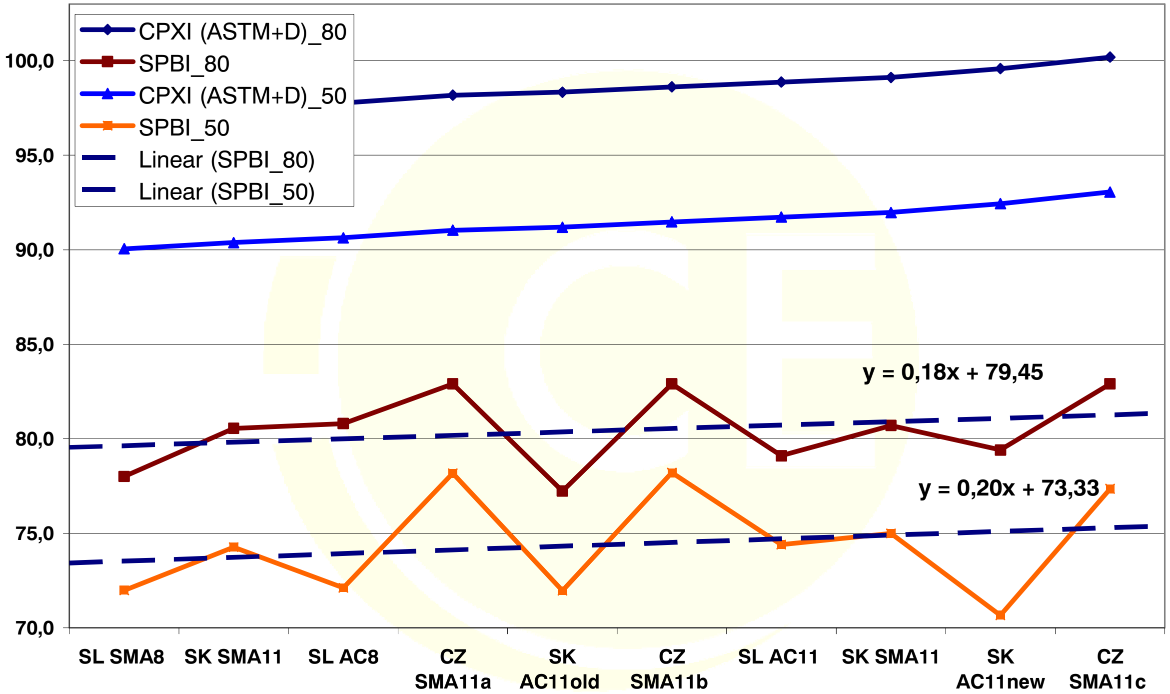
- e. g. 6 measurement sites tested at 50 km/h using ASTM SRTT
- similar energy content for each tested pavement
- shapes very similar for all the pavements (SMA8, SMA11, AC8, AC11new and AC11old)
- peak of the spectra is for all the pavements around 800 Hz.

Comparison of the three used tyres on the same pavement:

- e.g. SMA11 measured with 50 km/h reference speed in Slovakia
- similar shapes of the spectra
- peak for tyre ASTM and D at 800 Hz, peak for A tyre at 1000 Hz
- ASTM tyre: peak at 800 Hz is more acute but less energy content between 200 and 400 Hz

Correlation SPB-CPX

„Trend" correlation



Trend line of the SPB ranking has a good correlation with the CPX ranking (at 50 km/h and 80 km/h)

Pavements Ranking

		L_{cpx}		
Site	**Road surface**	**A @ 80 km/h**	**ASTM @ 80 km/h**	**D @ 80 km/h**
1	SL SMA8	97,8	95,7	97,6
2	SL AC11	97,6	96,2	97,9
3	SL AC8	98,3	96,6	97,9
4	SK SMA11	98,4	96,8	98,0
5	SK AC11new	98,9	96,9	98,0
6	SK AC11old	99,1	97,4	98,7
7	SK SMA11	99,4	97,5	98,8
8	CZ SMA11a	99,6	98,7	98,9
9	CZ SMA11b	100,3	99,3	99,6
10	CZ SMA11c	100,7	99,8	100,3

- Noise emission values of the tested pavements for each tyre at the same speed
- Results listed from the most silent to the less silent (different colours indicate to which pavements the results are referred to)
- Similar trends for the pavements ranking using different tyre

Conclusions from the CPX experiments

- CPX method (reference tyre A, D and ASTM SRTT) used for testing 11 different road surfaces in three European NMS (Slovenia, Slovakia and Czech Republic)
- Tested materials: SMA and AC with 8 and 11 chipping size
- Reference speed: 50 or 80 km/h
- Overall value LCPX: span of 4 dB → difference between noisy and quite pavements is rather small
- Good repeatability of the method → 0,15 to 0,40 dB std. dev.
- Frequency spectra: similar shapes for the same tyre over different surfaces, different shapes for each tyres
- Correlation with SPB results was not satisfactory for the singular indices (good trend line correlation between SPB and CPX ranking)
- Global ranking of pavements for each tyre and for both reference speeds → similar trend especially for tyres A and ASTM SRTT
- ASTM SRTT tyre: good comparability to the reference tyre A → good correlation over different road section (offset of about -2 dB)

Part 4

CONCLUSIONS AND RECOMMENDATIONS

Recommendations concerning air pollution by PM

- The contribution from pavement wear can be significant
- Pavements contribution to PM emissions can be adjusted through using other stone material and constructions
- Soft stone material produces higher total PM emissions
- Softer stone material reacts much stronger to speed changes, avoid where speed or direction changes are likely
- Harder stone material tends to have a higher emission of small-size particles below 1 µm (more dangerous)
- Winter tyres produce considerably more particles than summer tyres
- Asphalt pavements are less resistant to abrasion than cement concrete and produce more total PM
- However beware of very fine particles (found in one location with SMA)

Recommendations concerning noise emission 1

- Perform SPB and CPX measurements before and after pavement maintenance or replacement
- SMA pavements or AC pavements with low maximum chipping sizes show good results
- Replacing old pavements almost always reduces the noise emission
- Implement a noise classification system with a reference surface, conformity of production checks and monitoring (see SILVIA project)
- Use the SPB method (ISO 11819-1) and the CPX method (ISO/CD 11819-2) for classification
- CPX is preferred for conformity of production testing and monitoring

Recommendations concerning noise emission 2

- In general noise emission of road pavements increases over time
- The acoustically viable working life is shorter than the working life from a purely mechanical point of view
- Maintenance and timely rehabilitation are important, because the noise emission rises through degradation like cracking and raveling, potholes and any irregularity introducing step changes in the road surface level
- No general recommendation for asphalt or concrete surfaces in terms of noise emission can be given
- The most silent road surfaces today: porous asphalt pavements (with a shorter working life)
- Alternatives: open graded asphalt surface types, low-noise SMA types, exposed aggregate concrete road surfaces
- Loudest road surfaces: old concrete road surfaces with unfavourable surface treatments like transverse brushing and block pavements.

Thank you for your attention!