SEVENTH FRAMEWORK PROGRAMME

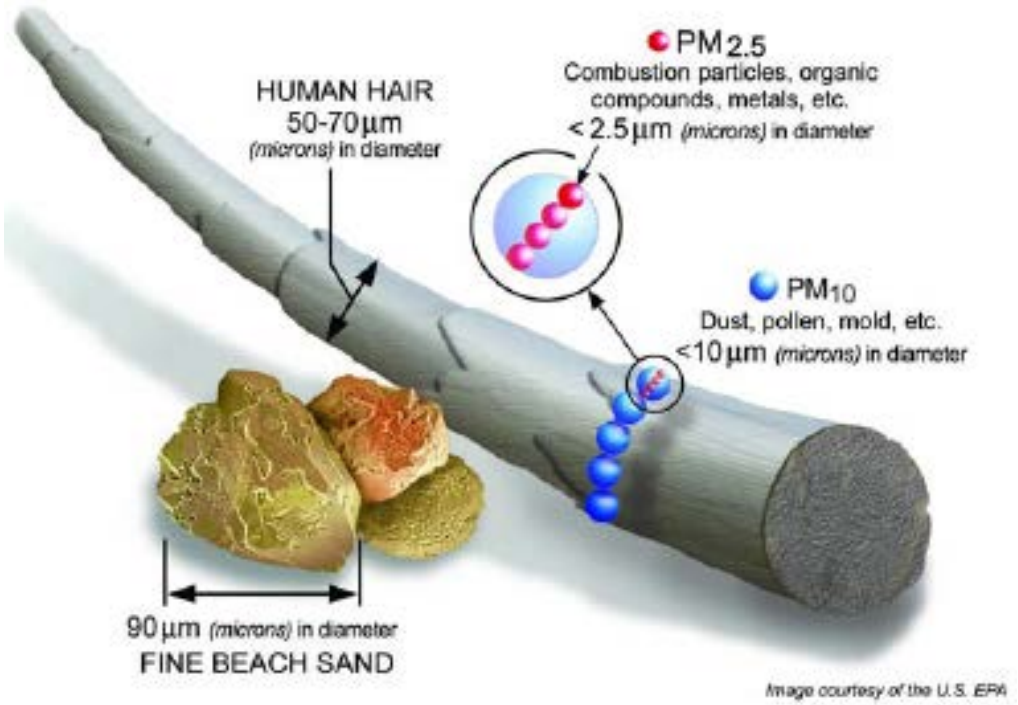
PmP Meeting
01-10-2014

Outline

- Background
- The REBRAKE project
- Testing set-up
- Testing parameters
- About sampling

Particulate Matter

Particulate matter is a general term used for a mixture of particles (solid and liquid) suspended in the air.

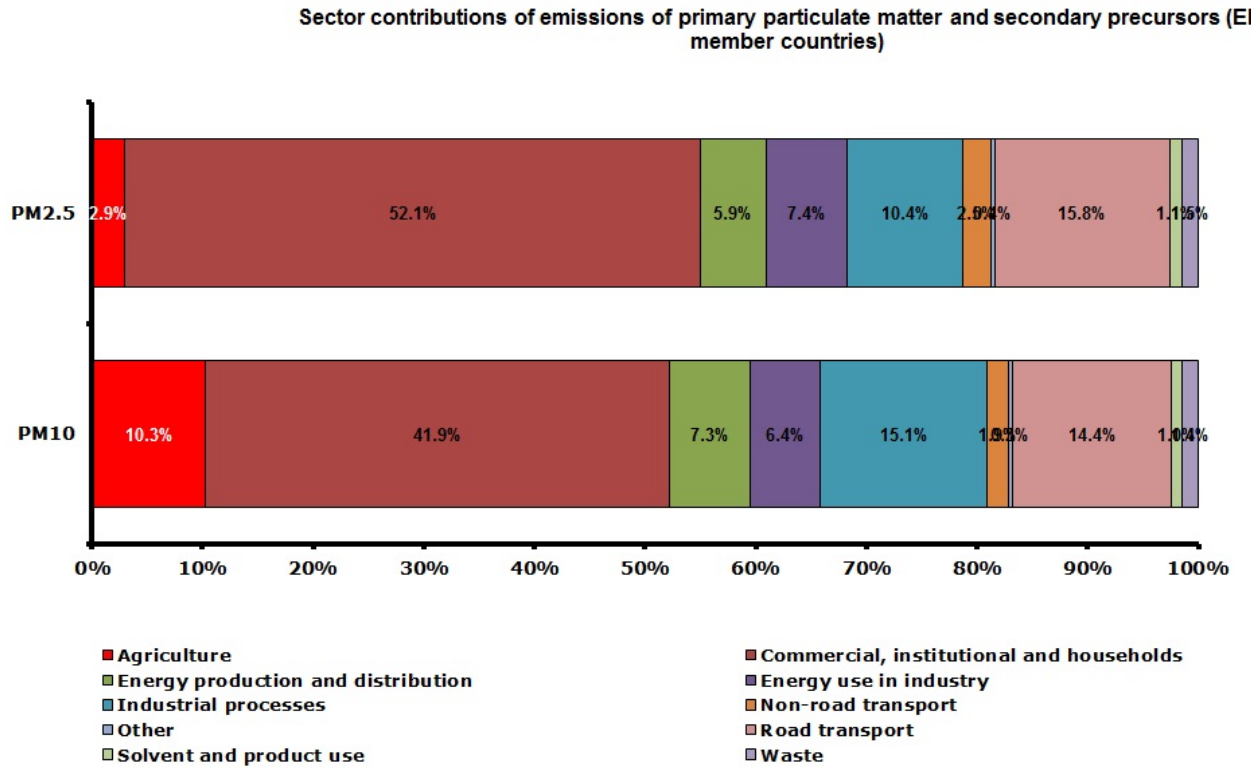


PM10-PM2.5Coarse fraction:
10µm<D<2.5µm

PM2.5-PM0.1 Fine fraction:
2.5µm<D<0.1µm

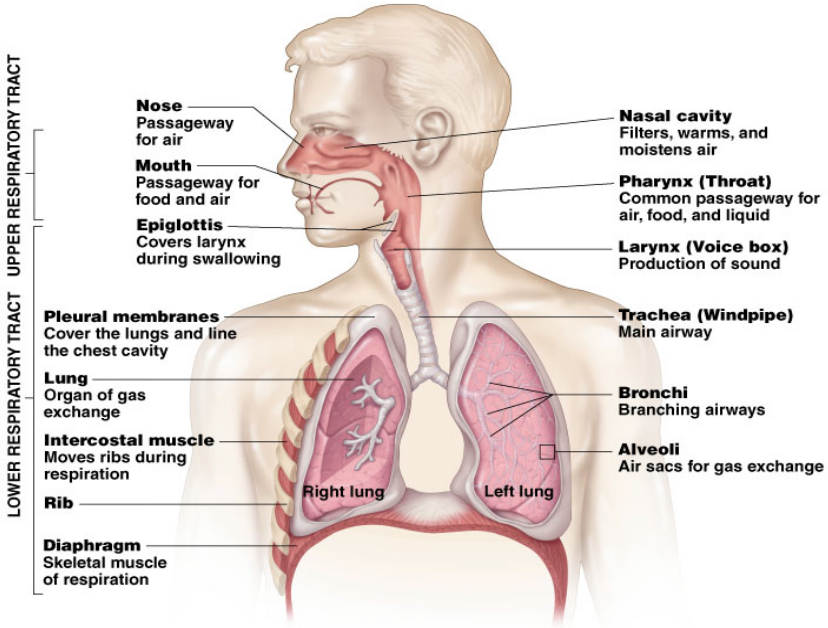
PM0.1 Ultrafine fraction:
D<0.1µm

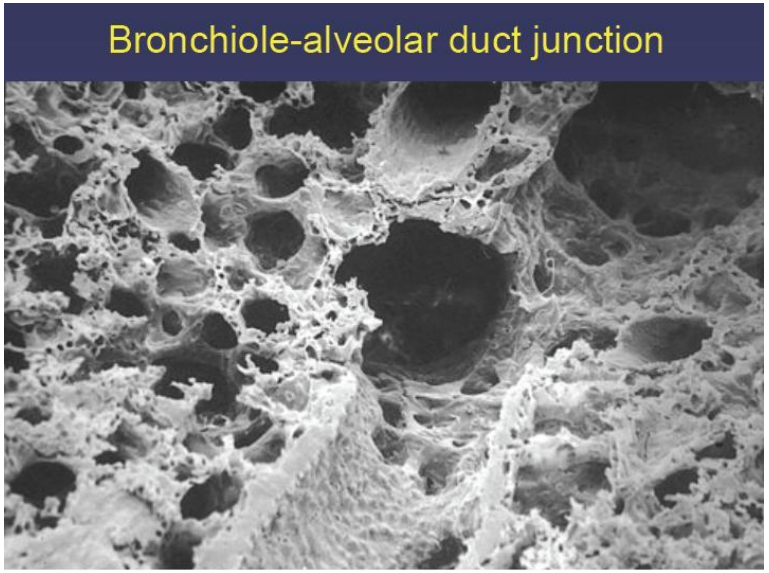
EU Particulate Emissions



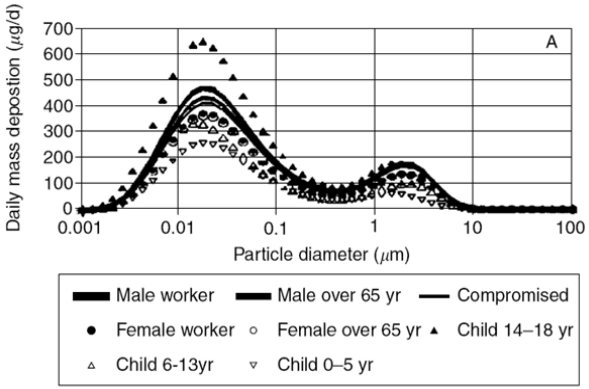
Road Transport contribute to 14.4% PM10 and 15.8% PM2.5 emissions in the EU. Related to those emissions, non-exhaust fraction equals the 50% of the exhaust one

Particles and Health





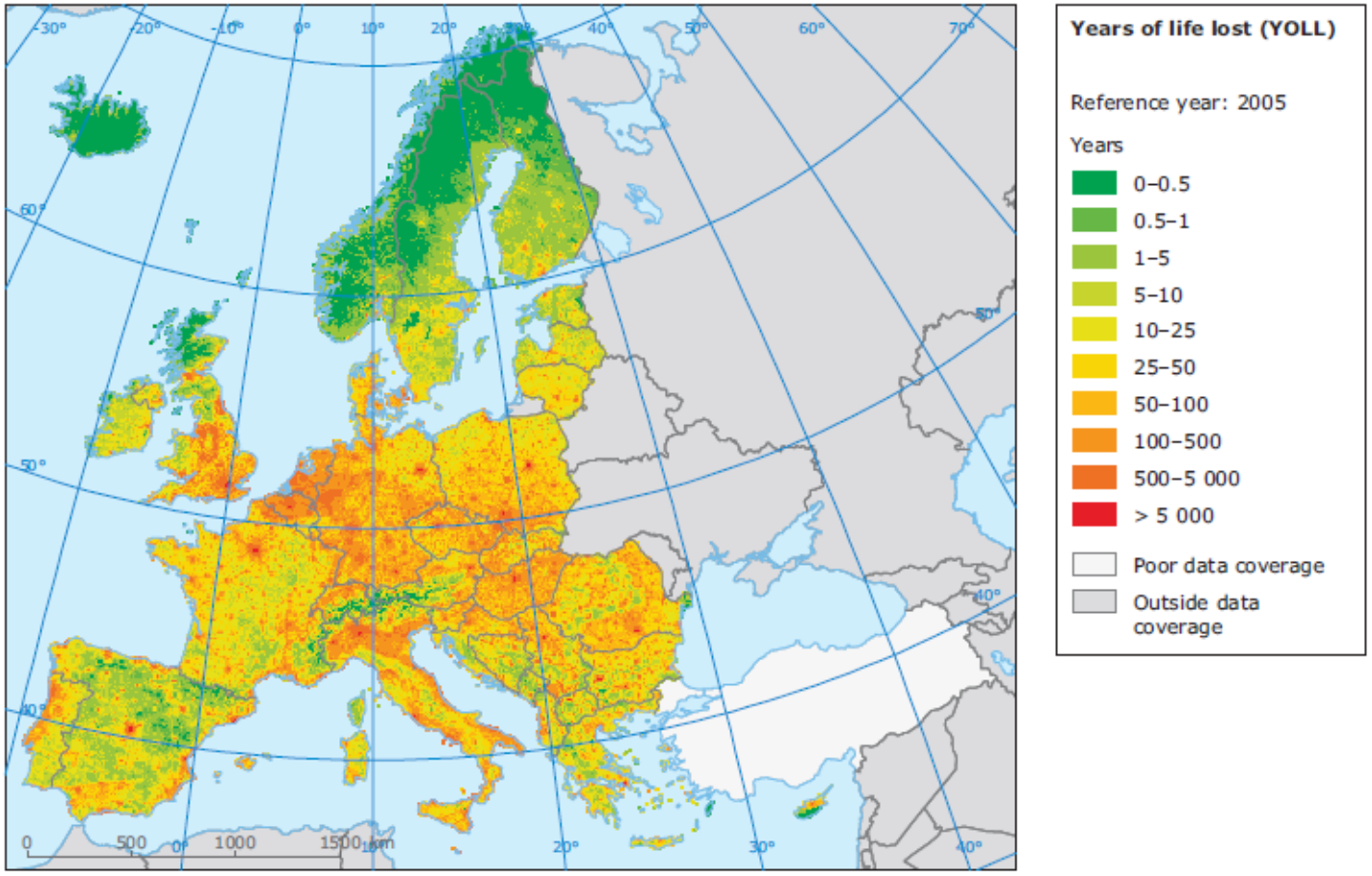
Paricle size range(μm)	***Level of penetration***
≥11	*Donot penetrate*
7-11	*Nasal passages*
4.7-7	*Pharynx*
3.3-4.7	*Trachea and primary bronchi (1st)*
2.1-3.3	*Secondary bronchi (2nd- 7th)*
1.1-2.1	*Terminal bronchi (8th)*
0.65-1.1	*Bronchioles (9th -23rd)*
<0.65	*Alveolar ducts (24th-27th) and alveoli*



Particles can have different health effects depending both on the particles size and the subject's biological characteristics

PM in Europe

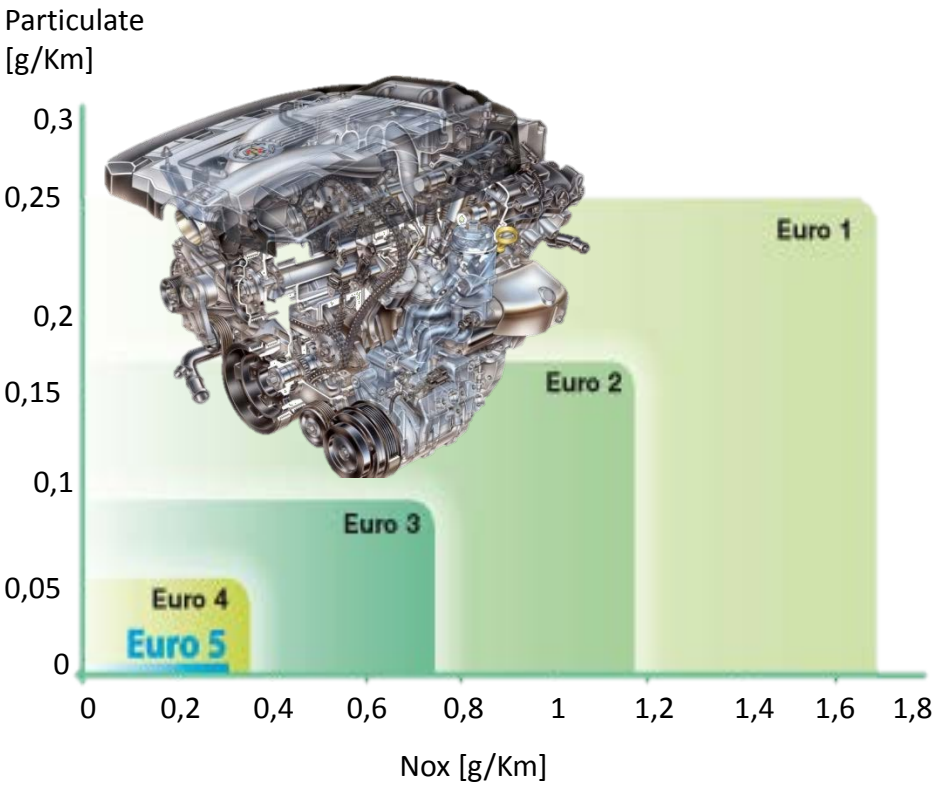
Map 2.1 **Years of life lost (YOLL) in EEA countries due to $PM_{2.5}$ pollution, 2005**



in EEA*-32 countries

5 million years of life lost in 2005 due to particle emissions

EU countermeasures



Today Engine emissions are well controlled and regulated (New Euro6 Standard coming out on September 2014)
but anything has been done for brake systems emissions yet

The REBRAKE Project

- **REBRAKE goals:**

1.	At least 50% particulate matter (PM10) mass reduction from brake wear, in compliance with the EU2020 thematic strategy of 47% reduction of particulate matter by 2020;
2.	Deeper comprehension of the physical and chemical phenomena underlying the brake wear process, including higher comprehension and analysis of characteristics coarse, fine and UFP particles.

- **Partners:**

Brembo S.p.a – Industrial partner

Kungliga Tekniska Högskolan – Academic partner

Università degli Studi di Trento – Academic partner

- **Project effort:** 211 men-months, Total funding: € 2.061.716,43
- **Project lenght:** 48 months; starting March 2013, 1st

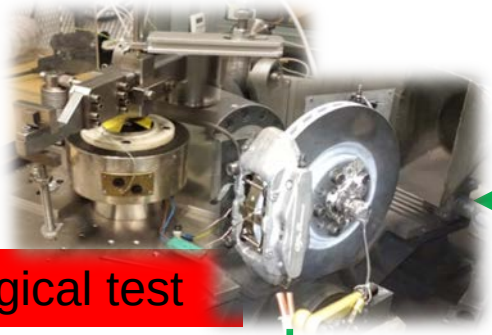
REBRAKE – project structure

IAPP project mission: Help public and private research pushing researchers and know-how exchange between industry and academy

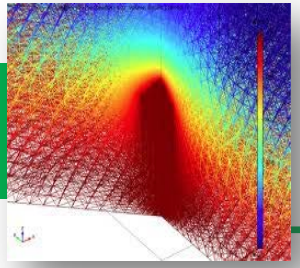
Involved researchers	Brembo	7
	KTH	6
	UniTN	4
Researchers secondment from Brembo to Stockholm/Trento		64 (51/13) months
Researchers secondment from KTH /UniTN to Brembo		75 (47/28) months
3 new employes for a 2 years period (one for each partner)		3x24 months

The final project effort is of 211 working-men months

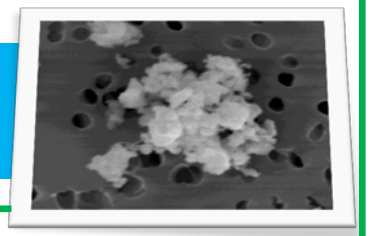
How does REBRAKE works



WP2. Tribological test



WP3. Wear and particles simulation



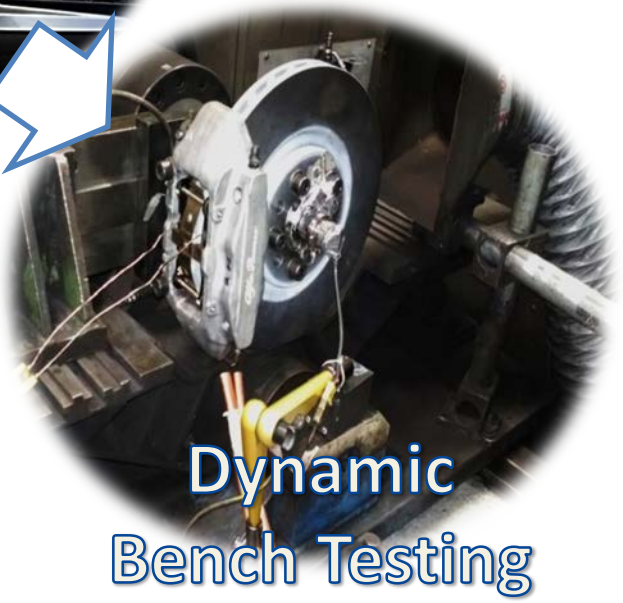
WP4. Particles characterization

WP5. Novel pad&disc formulation

WP1. Management

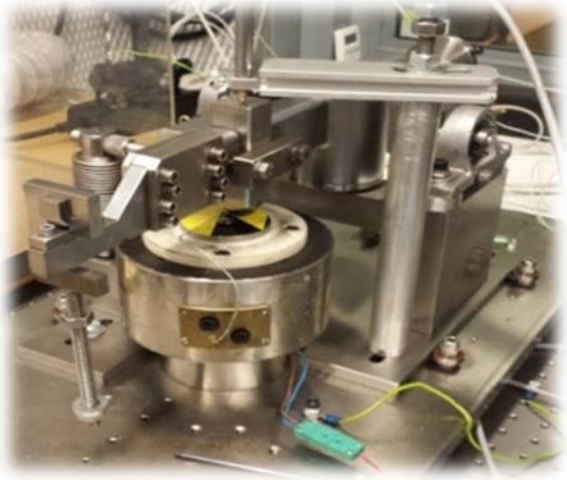
WP6. Dissemination

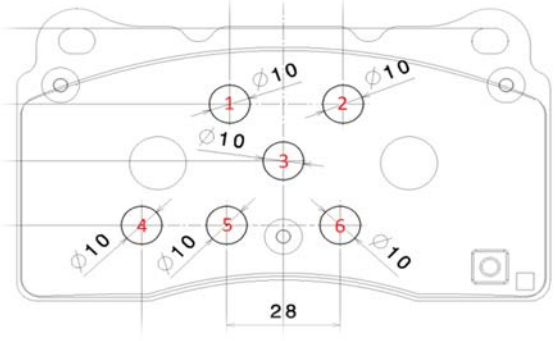
Reducing uncertainties

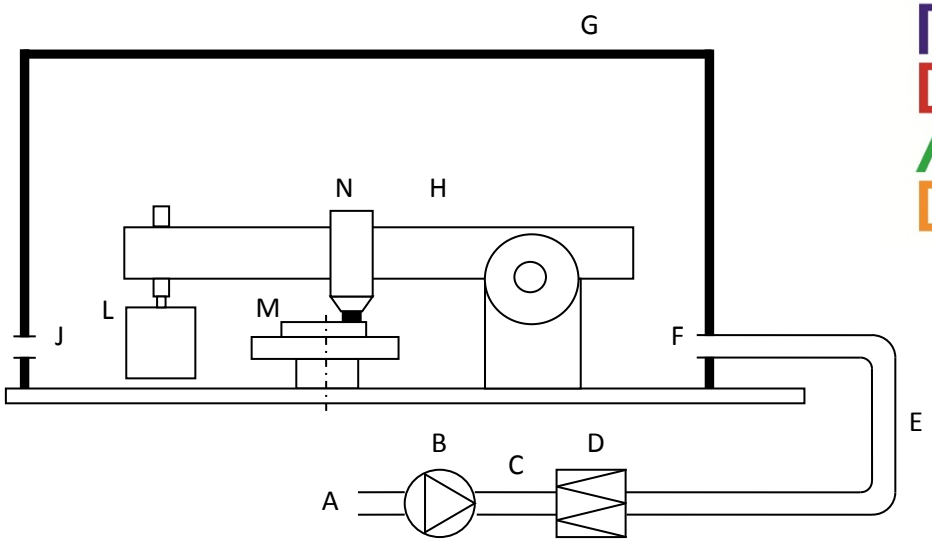


Different braking systems (disc-pad couplings) are going to be tested both in a Pin on Disc bench as well as in a real test bench, including disc coating solutions.

Pod test set-up







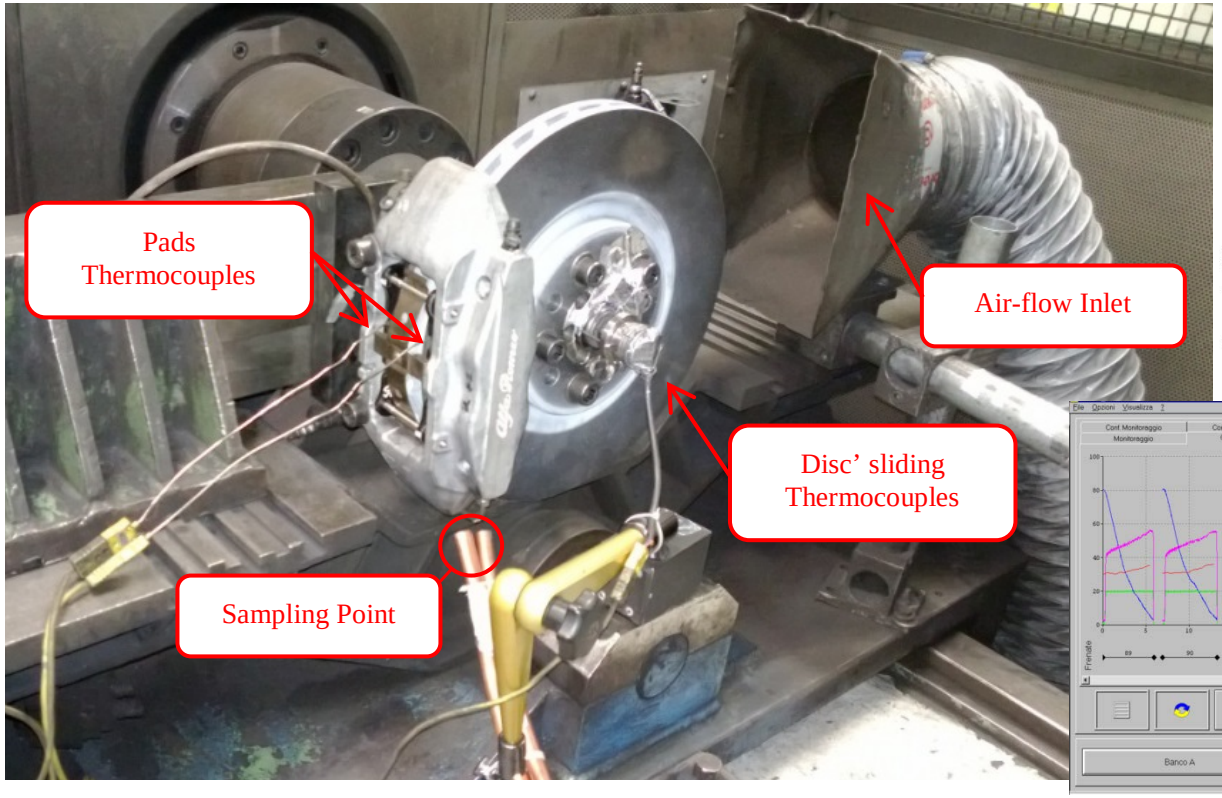
Schematic of the test equipment. A: Room air; B: Fan; C: Flow rate measurement; D: Filter; E: Flexible tube; F: Inlet for clean air, measurement point; G: Closed box (Chamber); H: Pin-on-disk machine; I: Air inside box, well mixed; J: Air outlet, measurement points; L: Dead weight; M: Rotating disk sample; N: Pin Sample.

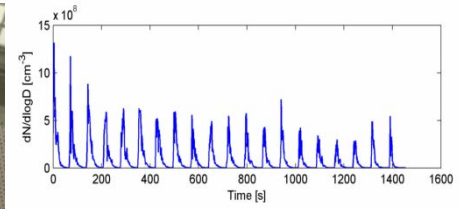
*Olofsson , Olander , Jansson,. 14. "A study of airborne wear particles generated from a sliding contact " Journal of Tribology Volume 131, Issue 4, October 2009, Page 1-5

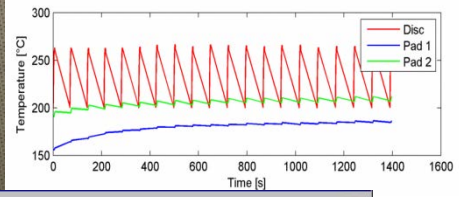
* Wahlström, J., Söderberg, A., Olander, L., Olofsson, U., Jansson, A. "Airborne wear particles from passenger car disc brakes: A comparison of measurements from field tests, a disc brake assembly test stand, and a pin-on-disc machine "(2010) Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology, 224 (2), pp. 179-188."

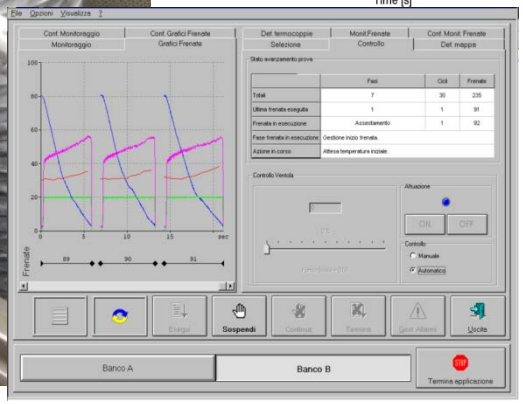
PoD tests aim is to deeper understand the basics of particle emissions under different working conditions and develop simple FEM models. Tests have all the same sliding distance, looking for a steady state, meanwhile the other parameters are modified.

Dyno test set-up









*Mattia Alemani, Ulf Olofsson, Guido Perricone, Jens Wahlström, Anders Söderberg, Alessandro Ciotti, "A proposed dyno bench test cycle to study particle emissions from disc brakes", Eurobrake 2014 proceedings

Dynamic Bench tests helps to understand the particle behavior under real working conditions. Recent updates includes a clean chamber and Isokinetic sampling.

Controlled parameters

Data	Pin On Disc	Dyno Bench
Wear	LVDT	Measured after test
Pressure	Imposed by load/pin	Applied
Tangential force	Load cell	Load cell
Friction	calculated	calculated
Disc Temperature	1 k-type thermocouple	1 k-type thermocouple
Pin Temperature	2 k-type thermocouples (different height)	2 k-type thermocouples (one for each pad)
Sliding velocity	Imposed	Imposed/measured
Flow rate	Imposed	Work in progress
Humidity	Hygrometer	Work in progress
PM/PN	Elpi+ (with collection) FMPS OPS	Elpi+ (with collection)

Towards system ranking

In order to move toward a standard for a system ranking procedure, at first SAE-J 2707 (Method B) has been proposed as representative.

Block	Initial Speed [km/h]	Final Speed [Km/h]	Initial Disc brake Temperature [°C]	Braking deceleration [g]	Number of stops [N]
Burnish	50	4	100	0.25	50
Town block #1	50	4	150	0.25	20
Highway block #1	150	80	150	0.4	10
Country road block #1	80	4	200	0.35	20
Country road block #2	100	4	125	0.4	20
Highway cycle #2	180	80	100	0.5	5
Town block #2	50	4	150	0.25	20
Country road block #3	100	4	125	0.4	20
Hill descent block	80	4	350	0.35	5

*Mattia Alemani, Ulf Olofsson, Guido Perricone, Jens Wahlström, Anders Söderberg, Alessandro Ciotti, "A proposed dyno bench test cycle to study particle emissions from disc brakes", Eurobrake 2014 proceedings

About Sampling

Up to 3 particles counters are simultaneously used, in order to check results reliability

Dekati®
ELPI+
6 nm – 10 µm
(Electrical/ Impactor)

TSI
FMPS
5.6 nm – 0.56 µm
(Electrical)

TSI
OPS
0.3 µm - 10µm
(Optical)

About Sampling

- The air inlet is subjected to a previous passage trough an high efficiency HEPA filter
- Before starting, a check to ensure a clean environment is done
- Particle collection is done using both polycarbonate and aluminum filters. The former allows better chemical analysis, the latter better optical analysis (SEM)

Compared to Exhaust emissions, non-exhaust emissions chemical analysis evidence metallic particles, such as Iron, Copper, Zinc, Manganese, Titanium, etc. in a broad size range, from ultrafine to coarse fraction.

*Wahlström J.,Gventsadze D., Olander L.,Kutelia E., Gventsadze L., Tsurtsumia O.,Olofsson U. " A pin-on-disc investigation of nanoporous composite-based and conventional brake pad material focusing on airborne wear particles. Tribology International, 2011, Vol.44(12), pp.1838-1843


Thank
you

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