

Legislation Euro 7 to mitigate brake and tyre wear emissions

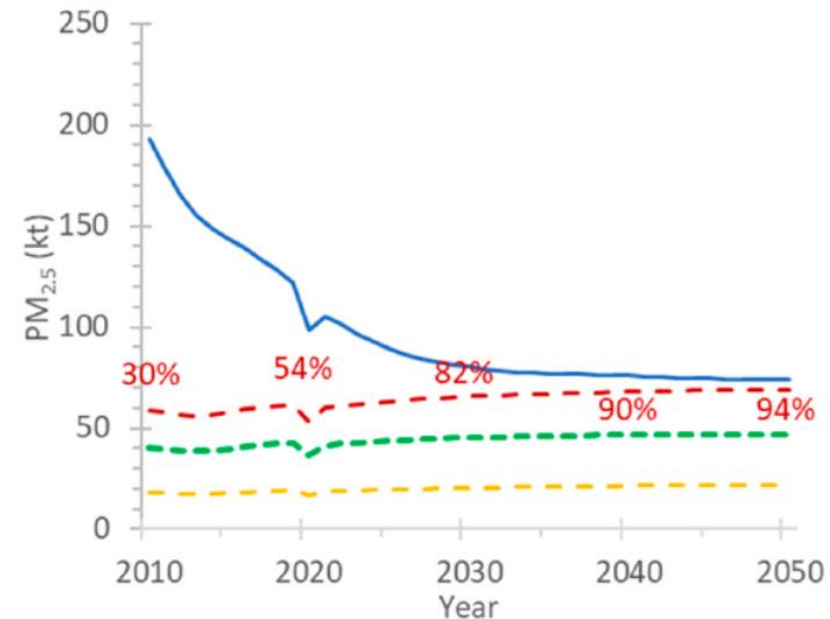
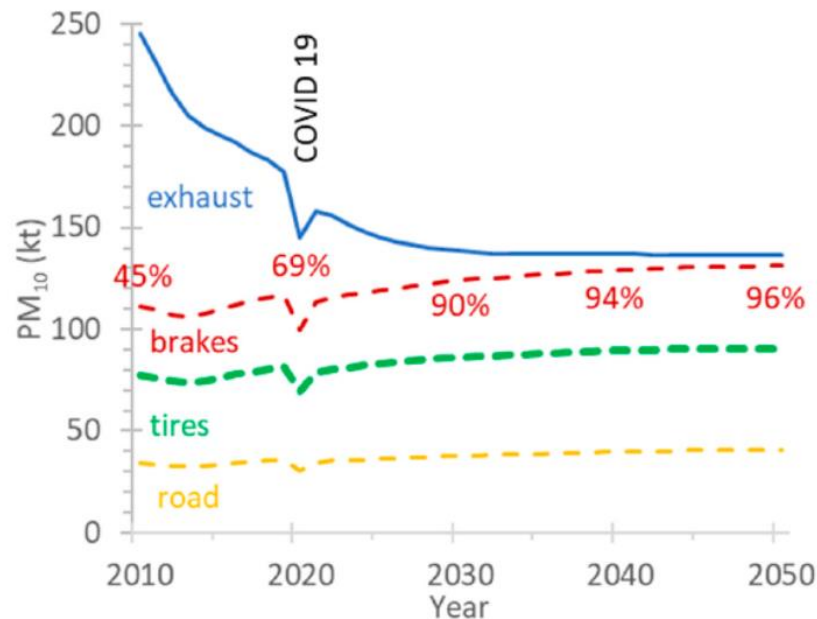
B. Giechaskiel and T. Grigoratos

Sustainable, Safe, and Smart Mobility Unit, Joint Research Centre

TFEIP 14/5/2024

Introduction

- The introduction of particulate filters and lately the electrification of the fleet have contributed to the vehicles exhaust particulate matter (PM) reduction
- Non-exhaust emissions since a few years have exceeded exhaust emissions and will become the main contributor to transport-related PM, if no action is taken.

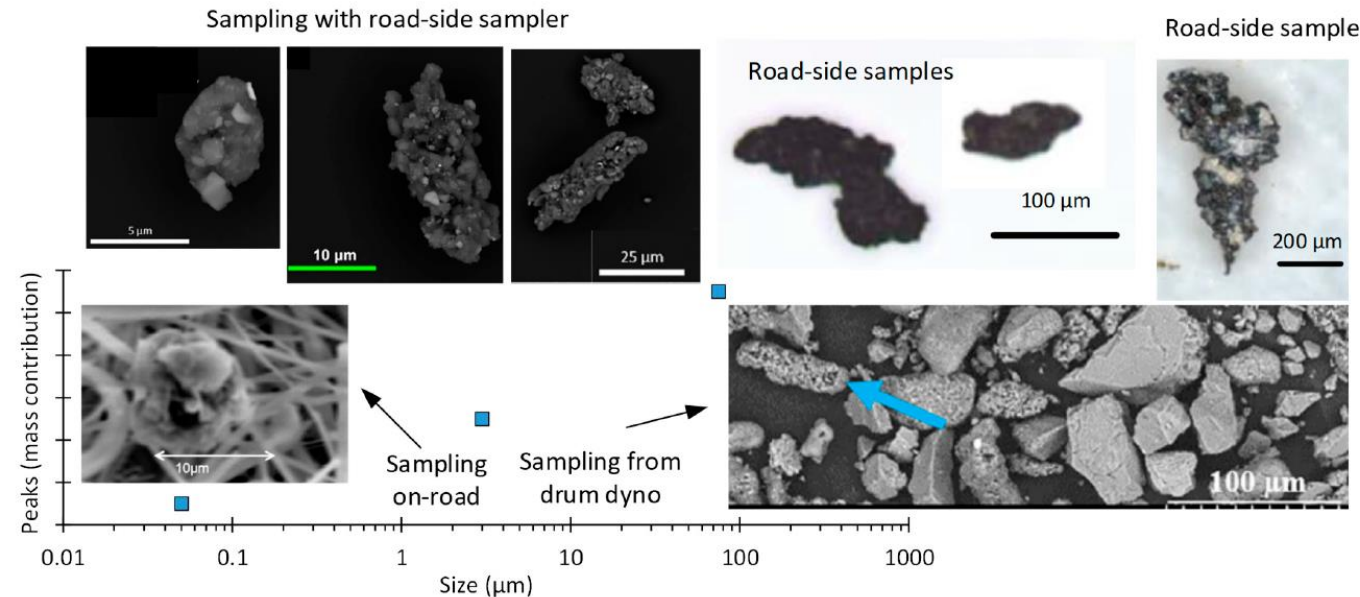
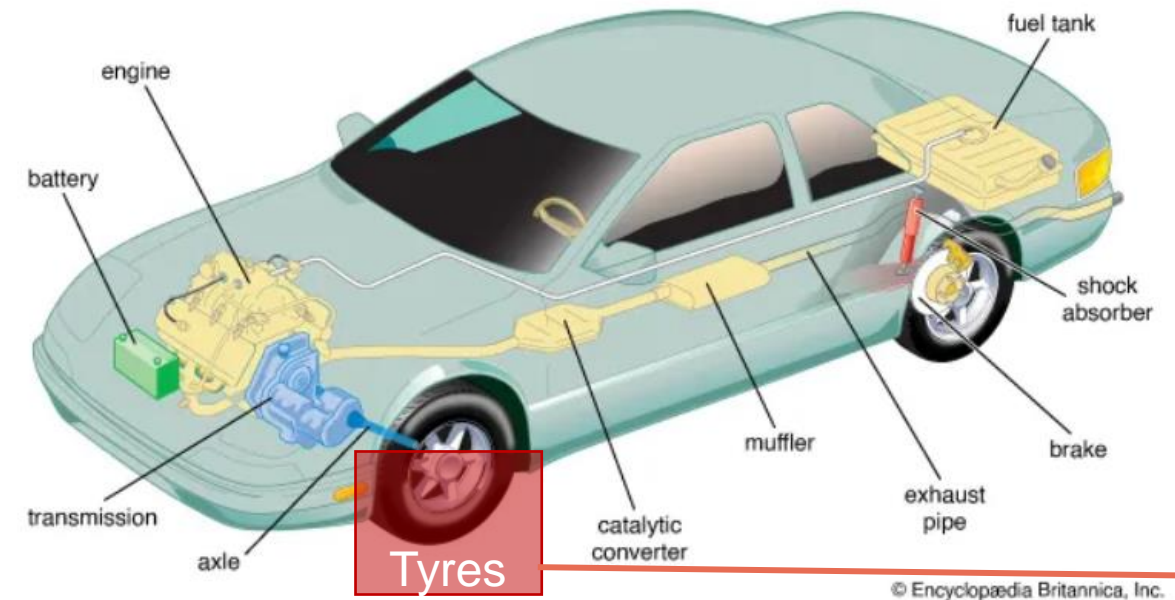


Euro 7 and non-exhaust particles

- The high non-exhaust emissions and their adverse effect to human health and environment, pushed the regulation authorities to establish emission standards
- In Euro 7, for the first time worldwide, non-exhaust emission limits for tyres and brakes are imposed
- Tyre abrasion methodology is based on mass loss measurement after on-road or laboratory measurement
- Regulation on brakes regards PM10 and solid particle number (PN10) measured in a brake dynamometer.

Tyres particles

- Tyre particles are generated by shear forces between the tread and the road pavement or by volatilisation
- Typically the particle size distribution of tyre particles is between 70 and 100 μm . Less than 10% is expected to be airborne (mainly PM10). Also ultrafine particles can be emitted due to volatilisation

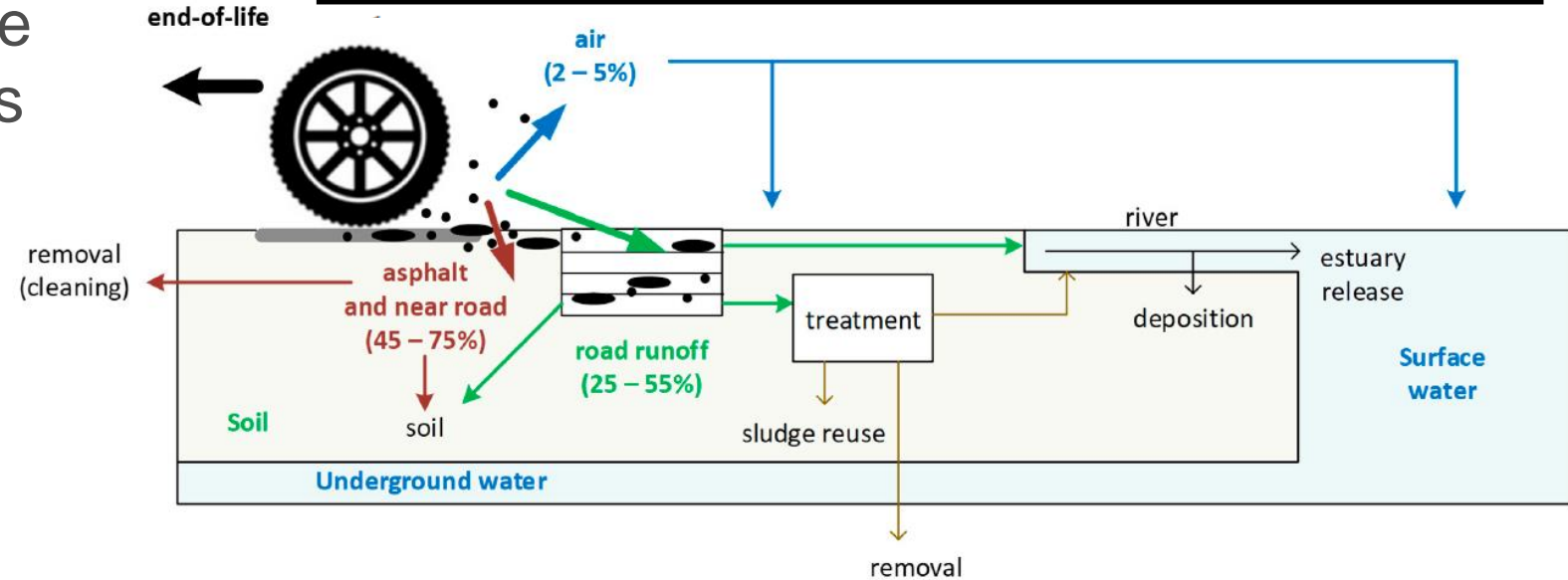


Tyres contribution to microplastics

Tyres are the biggest source of unintentional release of microplastics in the environment (heavier particles to water and soil)

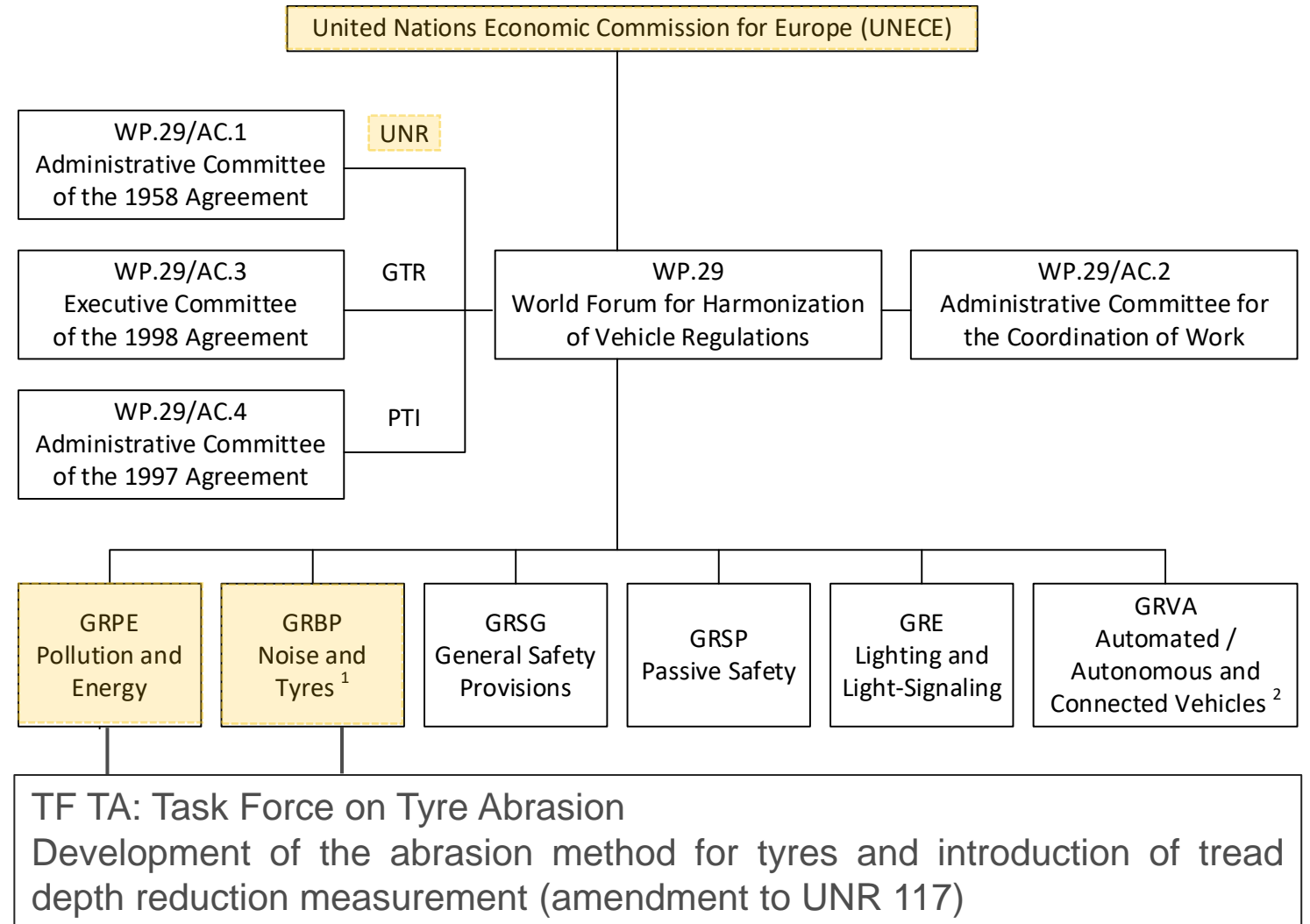
Most studies estimate one third to one half originates from tyres

Country	MP Emissions (kt)	Tyres' Contribution to MP Emissions
Norway	8.4	54%
Denmark	5.5–13.9	56%
The Netherlands ¹	5.4–32.9	11–96%
Sweden	10.5–13.5	60–77%
Germany	330	43%
Switzerland	87.8	93% ³
EU	787	64%
China	737	54%
Global	3000	47%
Sweden	9.6	85%
The Netherlands	7.6	35%
EU	450	36%
Global	800	62%



TYRE MICROPLASTICS – UN GRBP & GRPE (TF TA)

- The Euro 7 emissions proposal specifies “Based on the testing methodologies developed in UN for testing tyre abrasion in real world”
- The tyre labelling regulation (EU) 2020/740 provides the possibility to the EC to introduce abrasion in the label through a delegated act
- The procedures are being developed by the common GRBP/GRPE task force on tyre abrasion (TFTA)
- Work is still on-going



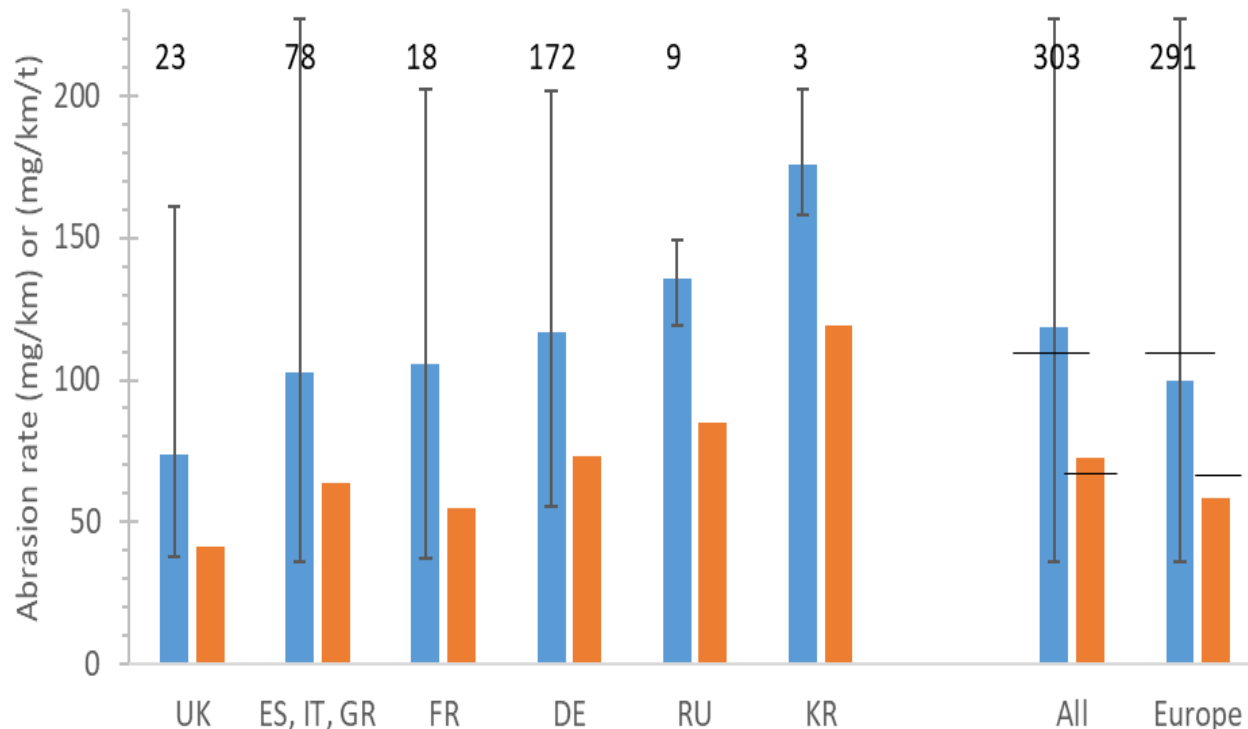
Euro 7 updates

- Tyres are divided in three classes: C1, C2, C3 (defined in UNR 117)
- Limits for normal, snow and special use tyres to be defined at the GRBP level (exception ice grip tyres). The limits have not yet been defined
- Method described in an amendment proposal of UNR 117, Annex 10 for C1 tyres (positively voted at GRBP).

Tyres Class	C1 (passenger car)	C2 (light truck)	C3 (heavy truck)
New types from	1 July 2028	1 April 2030	1 April 2032
All from	1 July 2030	1 April 2032	1 April 2034
Non-compliant in market until	30 June 2032	31 March 2034	31 March 2036

Abrasion rates

- JRC compilation of all recent data found a mean abrasion rate of 110 mg/km per vehicle (n=303), corresponding to 68 mg/km/t, even when considering only the studies from 2019 (n=289). Note that ADAC database is the largest (n=166).



- ❖ Mean abrasion rates of studies at different countries:
- ❖ 74-176 mg/km with a mean of 118 mg/km (73 mg/km/t)
- ❖ When considering only European studies: 100 mg/km (58 mg/km/t)

PM & PN from tyres

- The PN emission factors range mainly $1-10 \times 10^{10}$ #/km/tyre. The latest studies have an average value of 1×10^{10} #/km/tyre
- PM_{2.5}/PM₁₀ is on average 40%. The PM₁₀ is around 1.4-2.2 mg/km per tyre while the PM₁₀/abrasion rate is ~2.5%

Year	Ref	# tyres	PM ₁₀ mg/km	PM ₁₀ / abrasion	PM _{2.5} mg/km	PM _{2.5} / abrasion	PM _{2.5} / PM ₁₀	Comments
2005	[186]	2	[9-11]	-	1-2	-	0.11	Road simulator
2010	[179]	3 types	(0.9)	-	-	-	-	Up to 350 mg/km ¹
2013	[100]	1	-	-	-	-	0.73	On-road
2018	[154]	5	-	-	-	-	0.45	Road simulator
2018	[139]	4	[0.05]	1.5%	0.04	1.2%	0.82	Drum, abrasion 3.4 mg/km
2018	[116]	1	[0.01]	0.3%	0.00	0.1%	0.55	Drum, abrasion 3-9000 mg/km
2019	[216]	5	-	-	-	-	0.70	Drum
2020	[128]	4	1.9	-	-	-	-	Road simulator
2021	[178]	1	-	-	-	-	0.25	Abrasion device
2021	[150]	1	1.7	3.7%	1.3	3.3%	0.76	Drum-like
2022	[172]	3	2.2	-	0.4	-	0.16	Drum ²
2022	[187]	4	0.9	-	0.2	-	0.23	Drum
2023	[160]	3	-	2.4% ³	-	0.2%	0.08	On-road
2024	[217]	9	0.4	-	0.1	-	0.15	Drum
Average			2.2 [1.4] ⁴	2.5%	0.5	1.6%	0.42	
Weighted average			1.9 [1.1] ⁴	1.9%	0.3	1.0%	0.37	

Giechaskiel et al. 2024,
<https://doi.org/10.3390/su16020522>

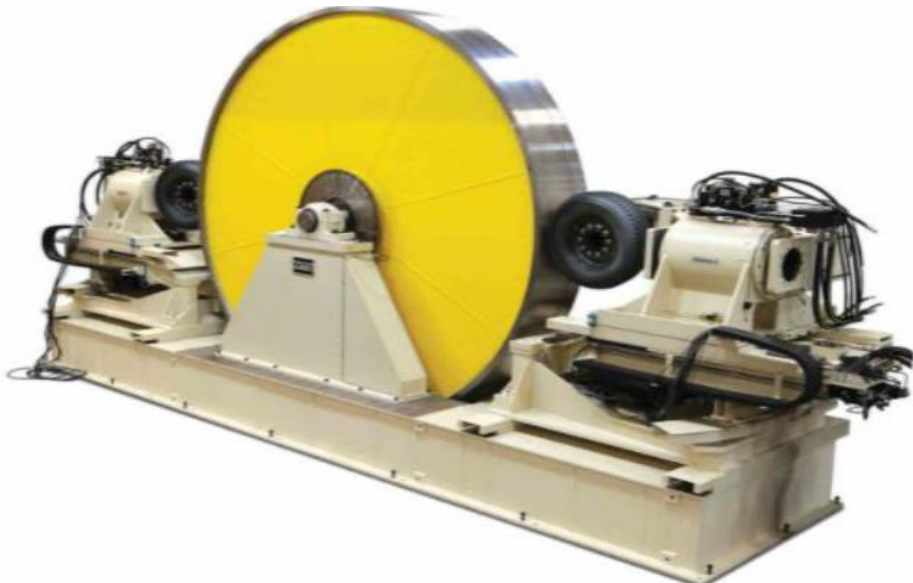
Tyres abrasion possible methods

On-road convoy method



- Convoy of vehicles with similar characteristics. Reference tyres on one vehicle to mitigate the impact of outside parameters on absolute abrasion rate;
- Circuit with public roads and shares of urban, regional, highway driving;
- Defined acceleration range and ambient temperature range.

Laboratory drum method



- The tyre is tested alone on a drum. Reference tyres is also tested against the candidate tyre to mitigate the impact of the sand paper on the abrasion rate;
- Cycle defined respecting shares of urban, regional, highway driving;
- Defined acceleration range and fixed ambient temperature range.

Mitigation measures

Reducing particles generation

Technology measures: improved tyres, reduced vehicle weight, speed/acceleration limiters

Management: Traffic flow and volume control, maintenance of roads and vehicles, public transport, taxation

Collecting particles (vehicle and road)

Tyre dust collectors

Asphalt with surfaces that trap particles

Reducing exposure and treating particles

Planting vegetation

Street cleaning

Treating road runoff

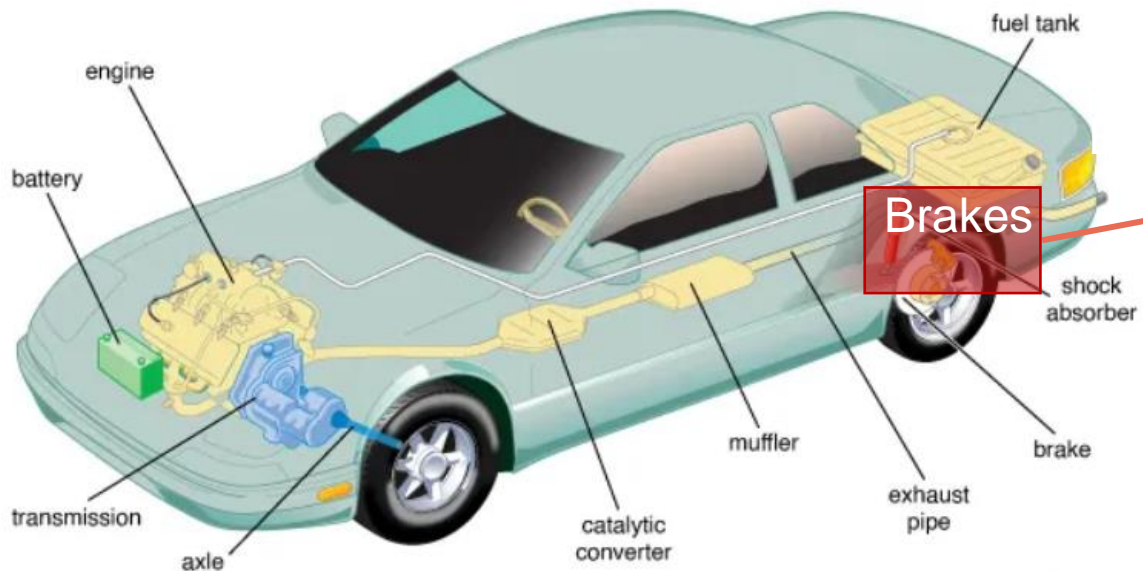
Addressing non-exhaust emissions more generally

Higher complexity of cost estimates

Less possibilities at EU level

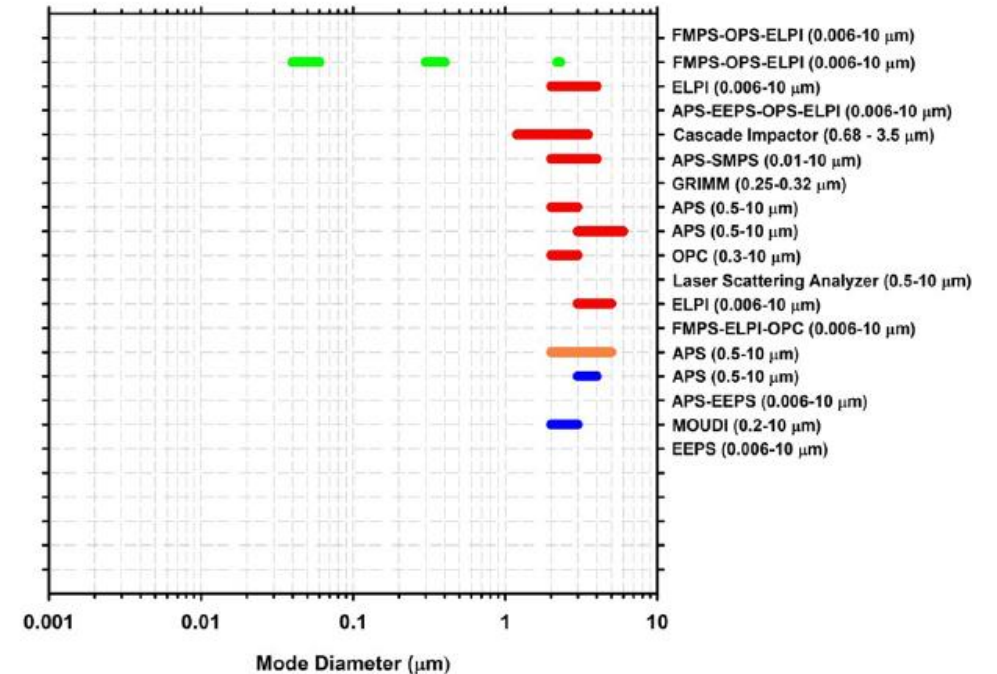
Brakes particles

- Brake particles come mainly from the friction between the brake pad/shoe and the disk
- They mainly contribute to PM_{2.5} but also to PM₁₀. According to literature brakes may also contribute to particle number



© Encyclopædia Britannica, Inc.

b) Brake wear mass-based particle distribution



Euro 7 emission limits

- Limits only for M1, N1 vehicles will be introduced at the first stage of Euro 7
- A limit will be imposed for PM10 and solid PN (>10 nm)

		until end 2029					from 2030 to end of 2034					from 2035	
		PEV	OVC	NOVC	FCV	ICEV	PEV	OVC	NOVC	FCV	ICEV	all	
M1, N1-I, N1-II	PM10	3	7	7	7	7						3	
	PN	-	-	-	-	-							
N1-III	PM10	5	11	11	11	11						3	
	PN	-	-	-	-	-							
M2, N2	PM10	-	-	-	-	-							
	PN	-	-	-	-	-							
M3, N3	PM10	-	-	-	-	-							
	PN	-	-	-	-	-							

N2/3 M2/3

Test Conditions

- Method described in GTR 24 (1st amendment to be voted at WP29 in June 2024).
- Laboratory brake dynamometer test with WLTP brake cycle
- Friction braking share coefficient as defined in GTR 24. Option for direct measurement on the chassis dyno or use of fixed coefficients

Table 4: Conditions for testing compliance with brake particle emission limits

	M₁, N₁ vehicles	M₂, M₃, N₂ and N₃ vehicles
Brake particle emissions test	Testing according to the UN GTR on brake emissions	

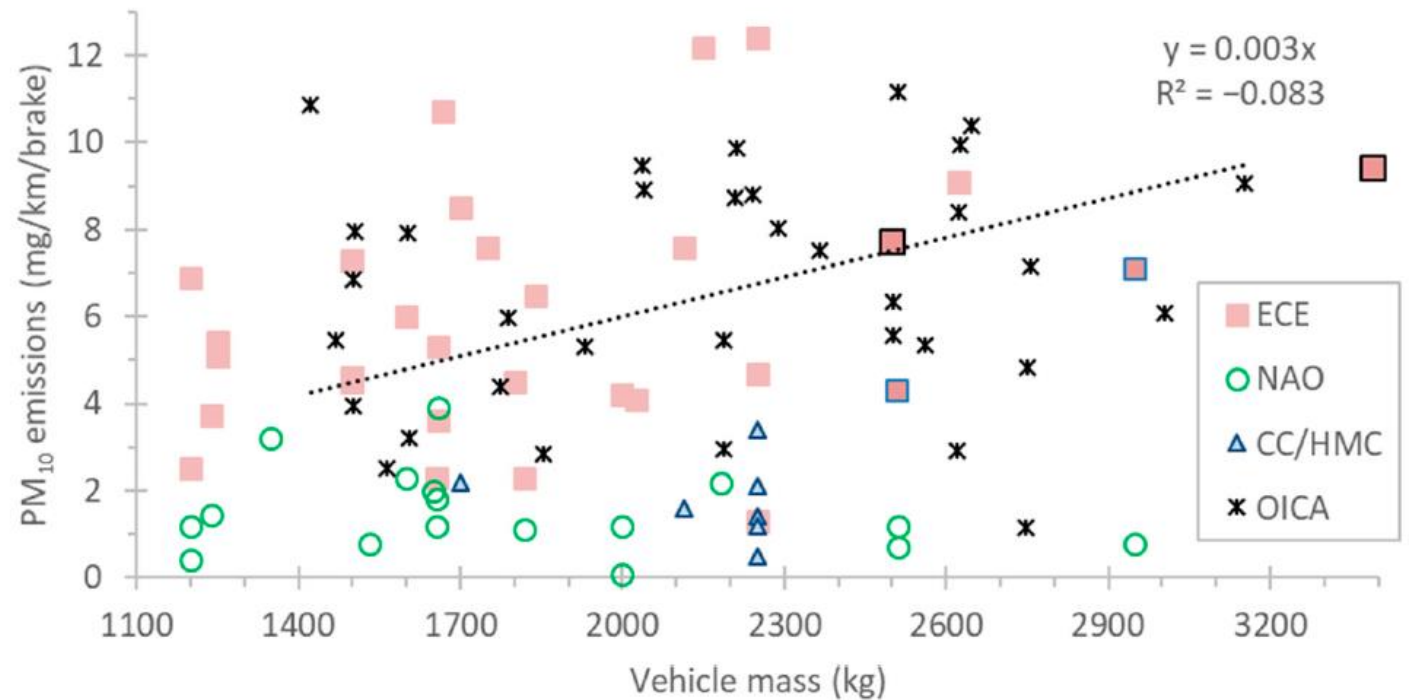
* PMP ToR: June 2025 text HD brakes ready (vote at GRPE)

Brakes EFs

Summary of studies that have followed the GTR24 procedure

High PM reduction potential

- NAO pads
- Coated discs
- Electrification
- Particle filters



Brakes EFs

Regenerative braking (see table)

Scenario	Mass kg	PM ₁₀ mg/km/V	PM _{2.5} mg/km/V	PN #/km/V
ECE	1525	13.4	5.5	9.1
ECE	1760	15.4	6.3	10.5
ECE	2250	19.7	8.1	13.4
ECE + Drum	1760	12.2	5.5	10.5
ECE + Drum	2250	15.3	6.7	12.5
NAO	all	4.7	2.2	2.1
NAO	1525–2250	5.4–7.9	2.5–3.6	4.1–6.0
CC/HMC + NAO	all	6.9	3.8	3.5

From ECE to NAO: On average, the reduction is 62% for PM10, 55% for PM2.5 and 64% for PN

From grey cast iron discs to advanced discs on average the reduction is 70% for PM10, and PM2.5 and 60% for PN

On average, passive systems have a PM efficiency of 50%, while active systems 75%.

Category	Regenerative Braking
Petrol	0%
Diesel	0%
HEV	10–48%
PHEV	66%
BEV	83%
other	0%

Conclusions

- Three novel building blocks of Euro 7 (brake particle emissions, tyre abrasion and battery durability) refer to existing or upcoming work developed in the UNECE World Forum for Harmonization of Vehicle Regulations (WP.29).
- Brake particle emissions, tyre abrasion and battery durability have their own timelines that reflect the expected developments in Geneva.
- Tyre abrasion based on convoy on-road method. Limits for C1 are expected in September 2025. Work for C2 and C3 tyres is ongoing
- Brake vehicle EFs of 13 mg/km (cars) to 20 mg/km (vans) have been estimated. NAO pads, advanced discs, regenerative braking and filters have demonstrated >60% reductions

Thank you



© European Union 2024

Unless otherwise noted the reuse of this presentation is authorised under the [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/) license. For any use or reproduction of elements that are not owned by the EU, permission may need to be sought directly from the respective right holders.

Slide 9: figures, source: ADAC and UTAC