Legislation Euro 7 to mitigate brake and tyre wear emissions

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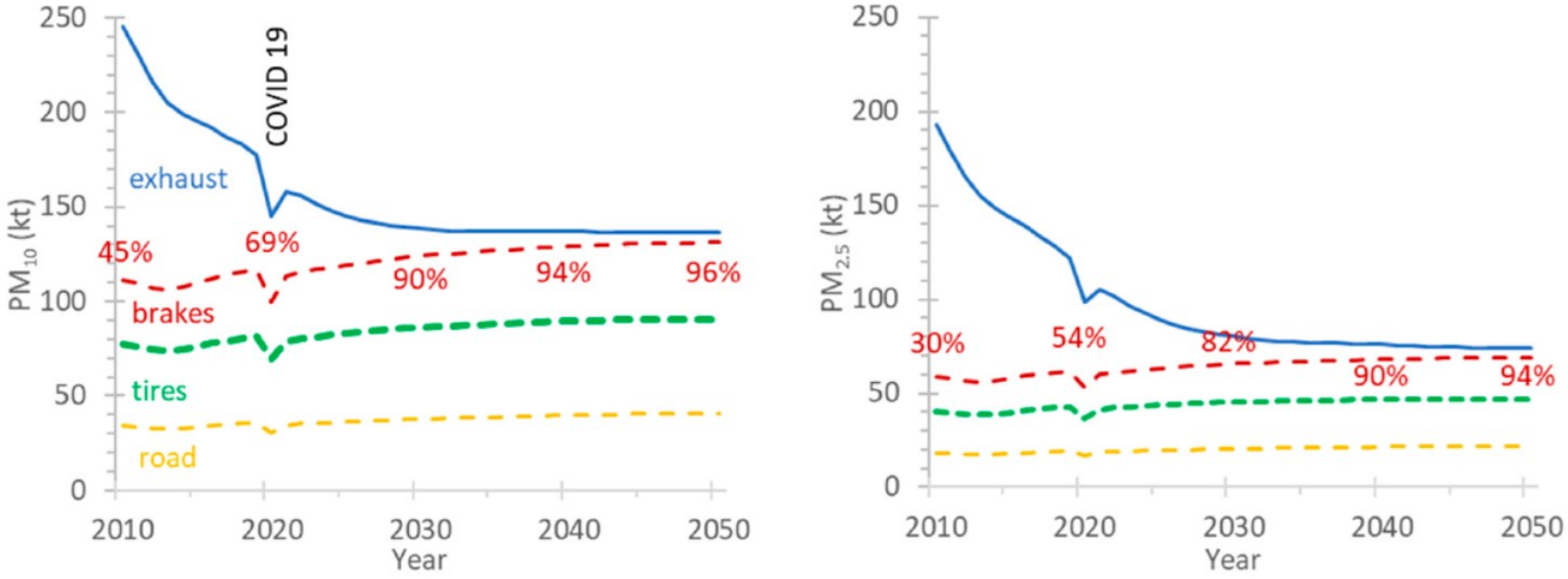
Introduction

- 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



B. Giechaskiel et al., Atmosphere 15 (2024) 97

Euro 7 and non-exhaust particles

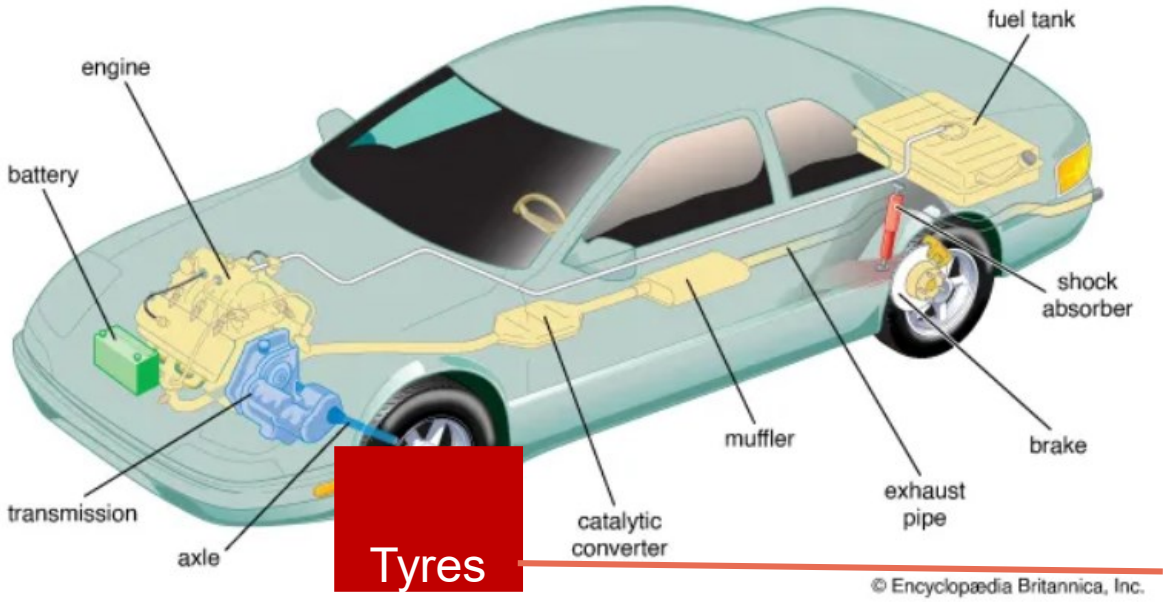
- The high non-exhaust emissions and their adverse effect to human health and environment, pushed the regulators to establish emission standards
- In Euro 7, for the first time worldwide, non-exhaust emission limits for tyres and brakes are imposed
- Tyre abrasion methodology is based on mass loss measurement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

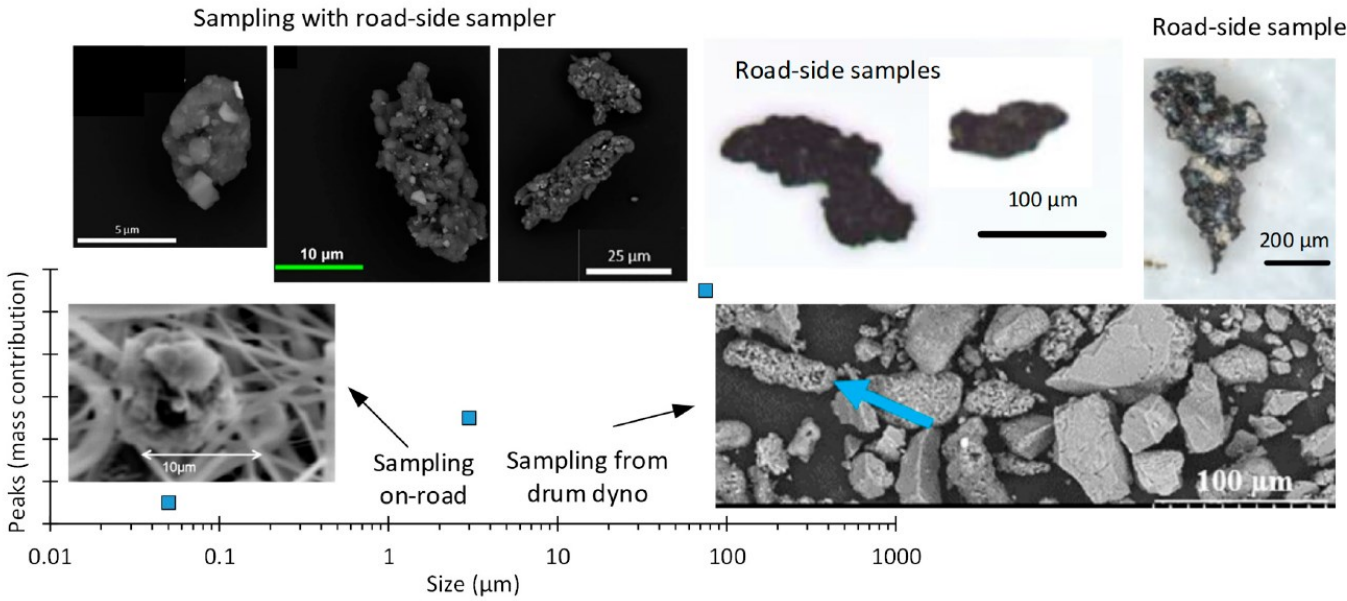
Tyre particles

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% of mass is expected to be airborne (mainly PM10). Also ultrafine particles can be emitted due to volatilisation





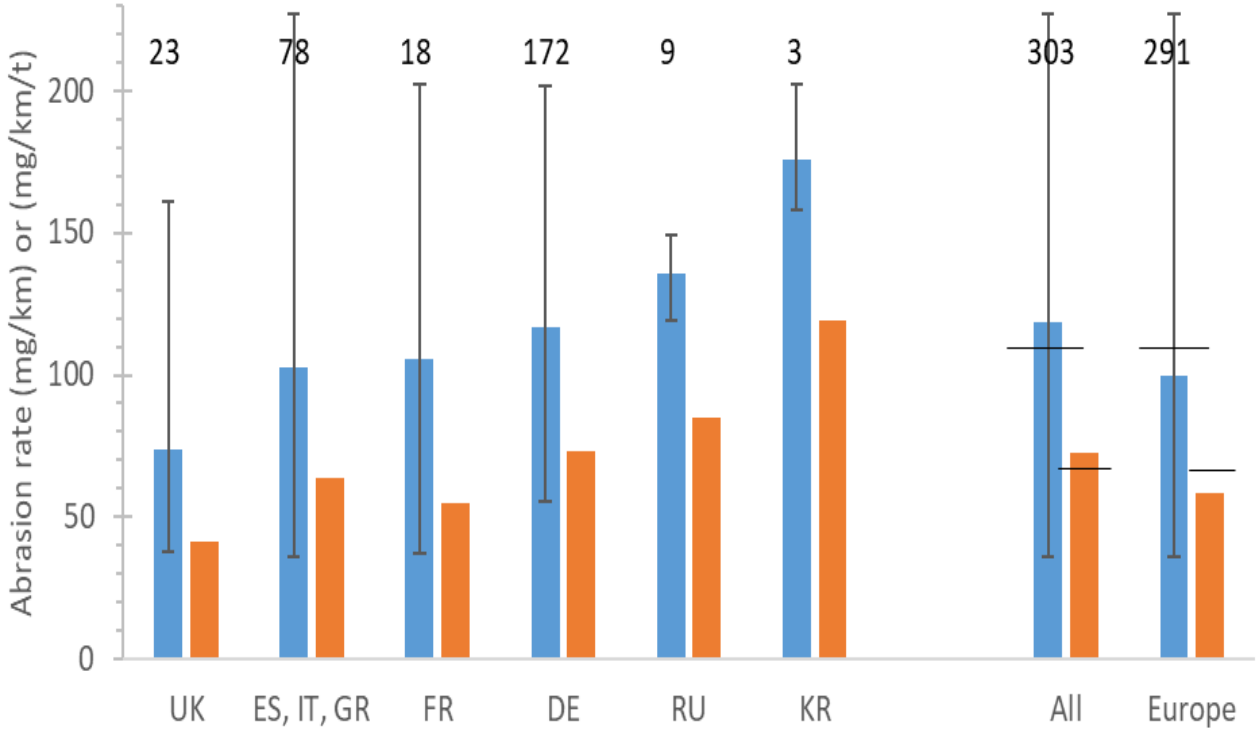
Tyres contribution to microplastics

- 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 (road transport)

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%

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)

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

PM & PN from tyres

- The PN emission factors range mainly 1-10x10^{10} #/km/tyre. The latest studies have an average value of 1x10^{10} #/km/tyre

- PM2.5/PM10 is on average 40%. The PM10 is around 1.4-2.2 mg/km per tyre while the PM10/abrasion rate (total mass loss) 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

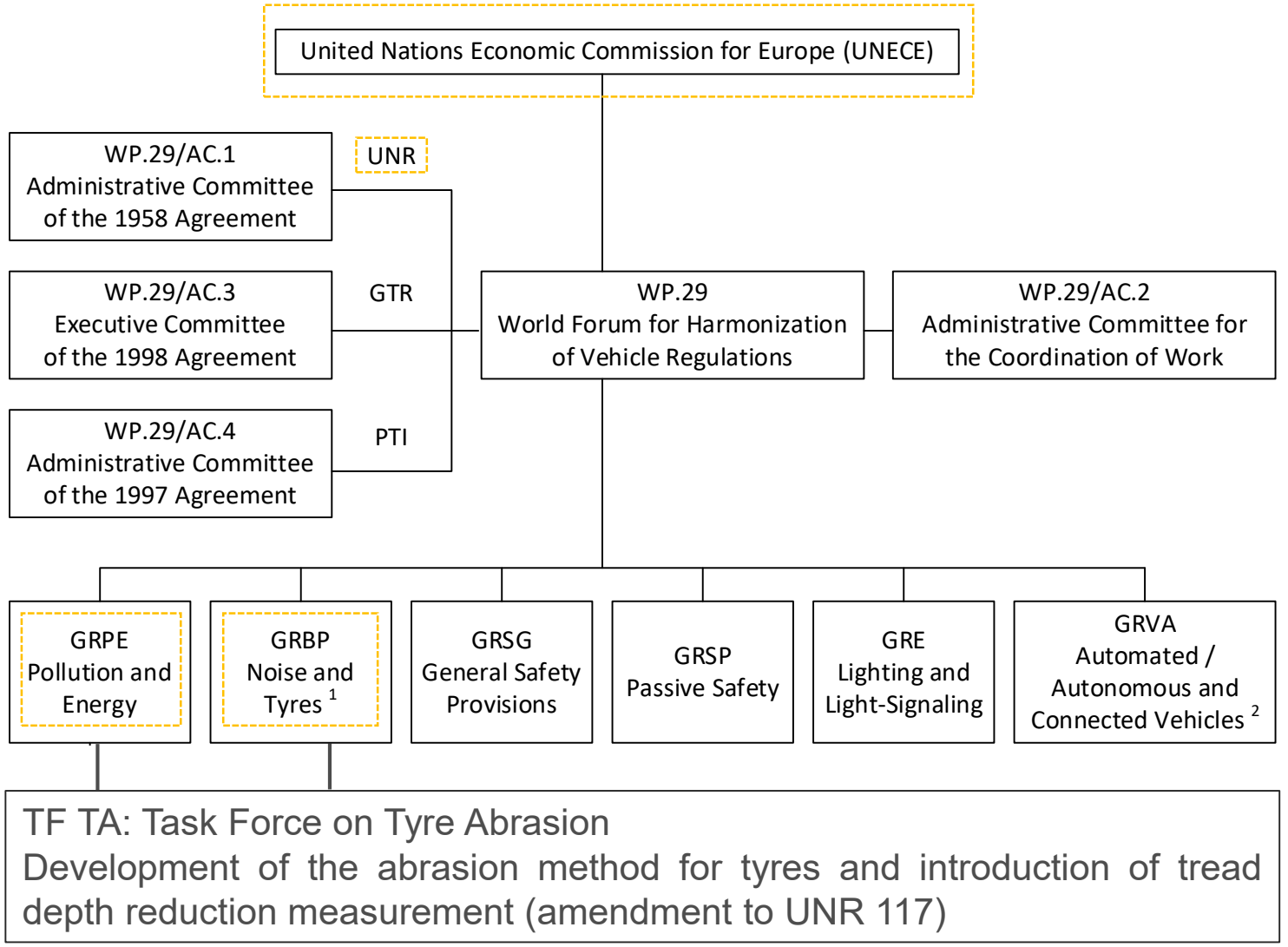
TYRE MICROPLASTICS – UN GRBP & GRPE (TF TA)

- 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 and tyres service life 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 ongoing



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).

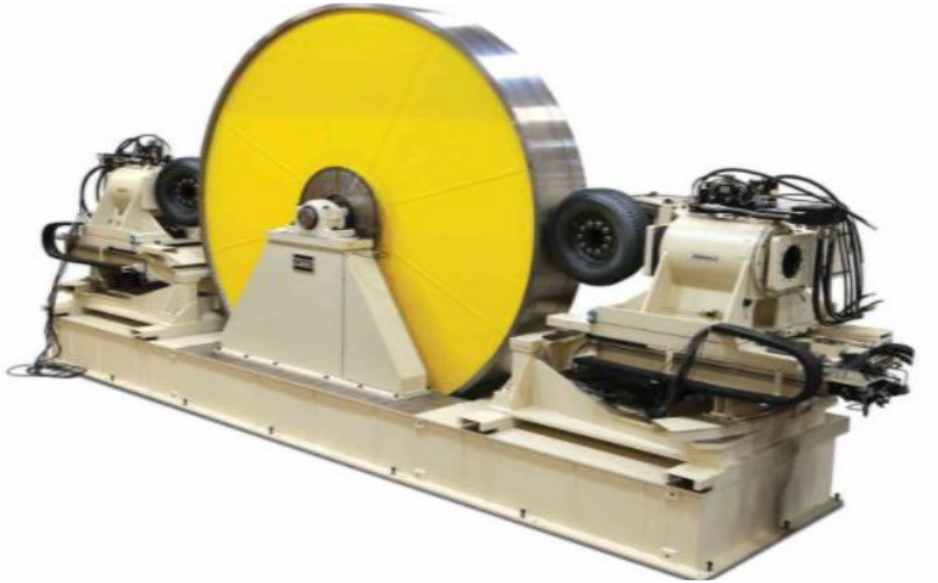
Tyres Class	C1 (passenger car)	C2 (light truck)	C3 (heavy truck)
New types from	1 July 2028	1 April 2030	1 April 2032
All from	1 July 2030	1 April 2032	1 April 2034
Non-compliant in market until	30 June 2032	31 March 2034	31 March 2036

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



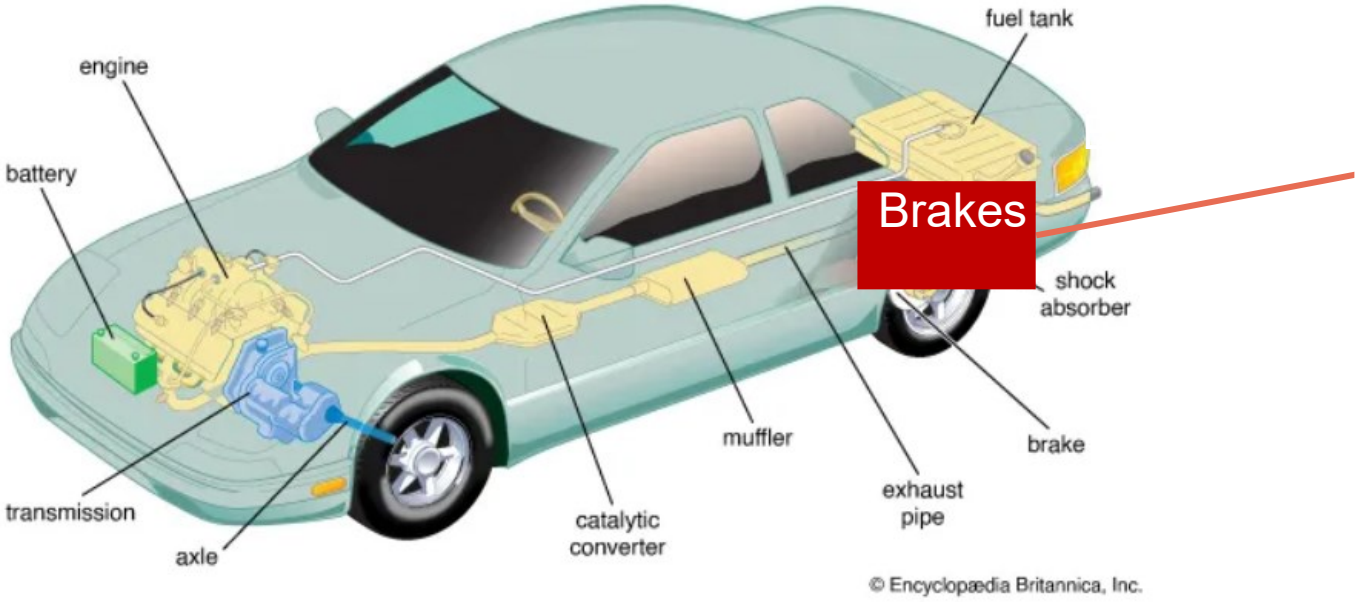
- The tyre is tested alone on a drum. Reference tyres is also tested against the candidate tyre to mitigate the impact of the sand paper on the abrasion rate;
- Cycle defined respecting shares of urban, regional, highway driving;
- Defined acceleration range and fixed ambient temperature range.

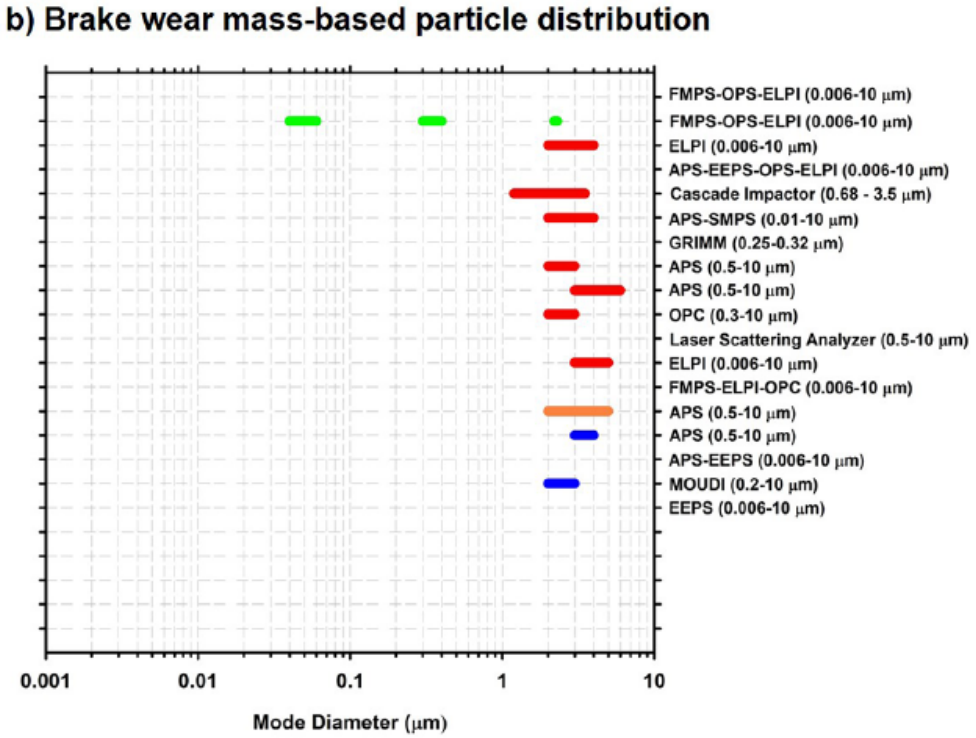
European Commission

Brake particles

Brake particles

- Brake particles come mainly from the friction between the brake pad/shoe and the disk
- They mainly contribute to PM2.5 but also to PM10. According to literature brakes may also contribute to particle number





Euro 7 emission limits

- Limits (mg/km) only for M1, N1 vehicles will be introduced at the first stage of Euro 7
- A limit will be imposed for PM10 and PN

		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

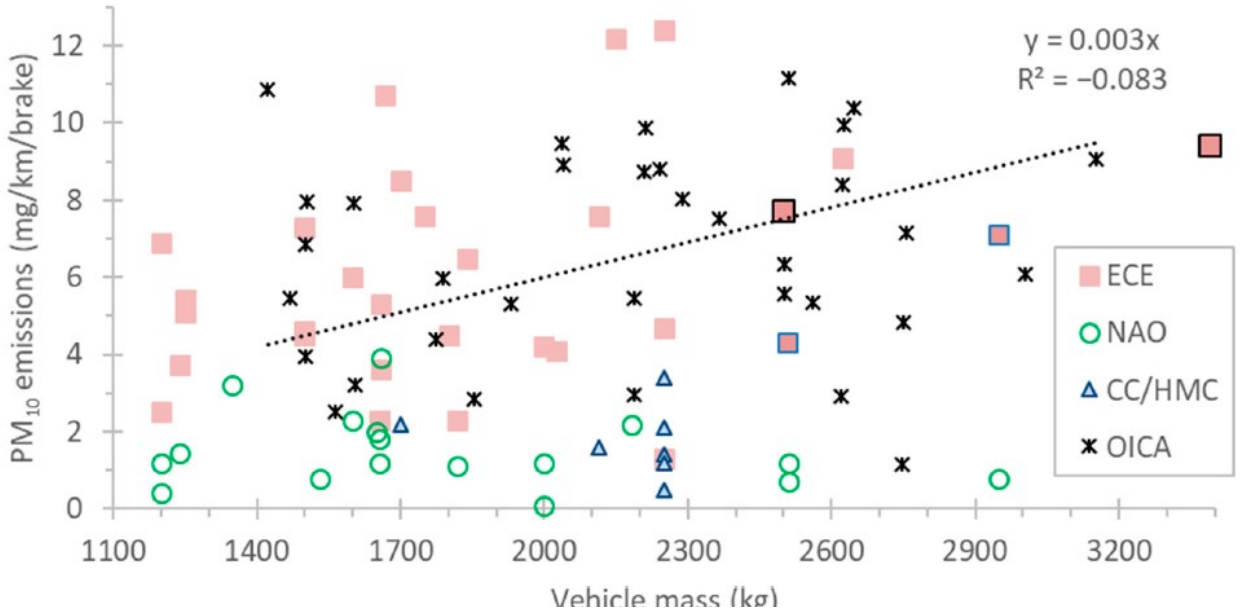
- Method described in GTR 24 (1st amendment to be voted at WP29 in June 2024).
- Laboratory brake dynamometer test with WLTP brake cycle
- Friction braking share coefficient as defined in GTR 24. Option for direct measurement on the chassis dyno or use of fixed coefficients

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

	M_1, N_1 vehicles	M_2, M_3, N_2 and N_3 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



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

- Summary of studies that have followed the GTR24 procedure
- High PM reduction potential:
  - NAO pads (compared to ECE): average reduction of 62% for PM10, 55% for PM2.5, and 64% for PN
  - Advnced discs (compared to grey cast iron disks): average reduction of 70% for PM2.5 and PM10, and 60% for PN
  - Particle filters (active systems have PM efficiency of 75% and passive 50%)
  - Electrification: depending on the degree of electrification

Giechaskiel et al. 2024, https://doi.org/10.3390/atmos15010097

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

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Thank you

Slide 9: figures, source: ADAC and UTAC