



# OICA views on brake wear particles

29 November 2021

A contribution from the global automotive  
industry



# AGENDA

- 1. ACEA brake wear measurement campaign**
- 2. Particle measurement deviation**
- 3. Thoughts on emission reduction potential**
- 4. Measurement procedure for regenerative braking**
- 5. Test procedure boundaries – brake temperature**
- 6. Light Commercial Vehicle issues**
- 7. Summary**

# ① PARTICLE MEASUREMENT DEVIATION

**ACEA Measurement campaign** (in addition to PMP ILS)

for conventional series brakes, according to PMP measurement protocol

Example of the ACEA data base:

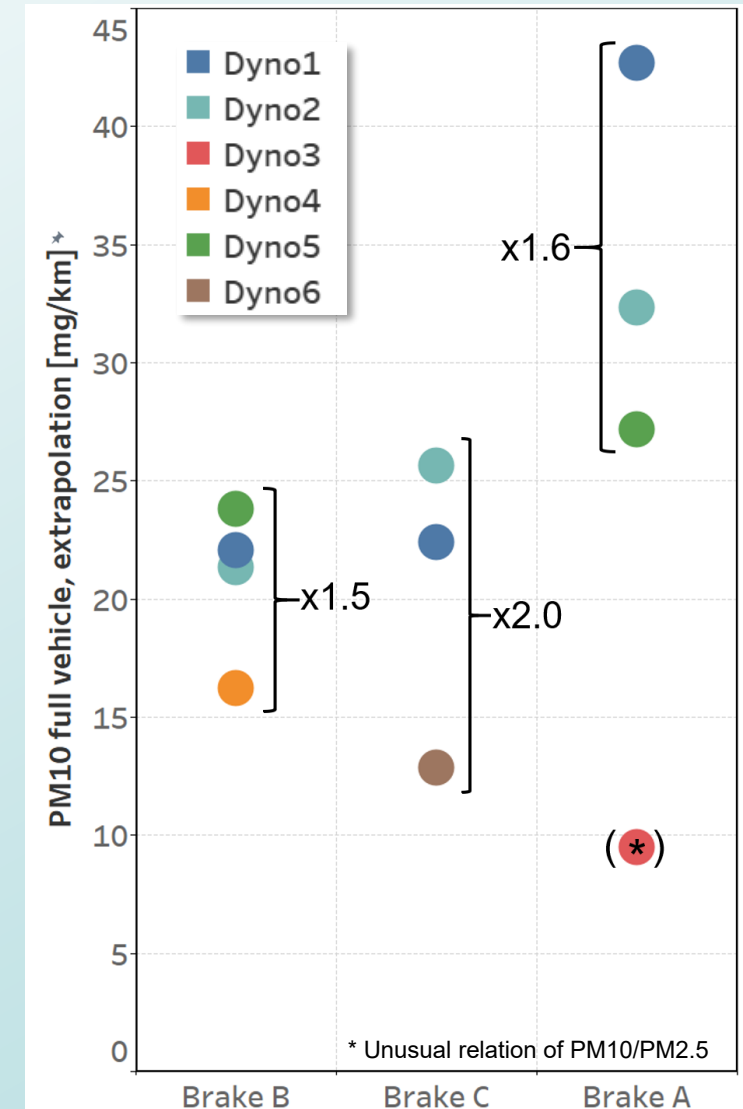
- Three brake systems have been measured at different dynos (complying to current PMP draft)
- Dyno-to-dyno variation up to a factor of 2 for PM10 is observed
- How can the impact of additional brake system improvements be evaluated with such large deviations?

**The shown deviations are to a large extent based on differences in test setup & method (while compliant with PMP draft)**

What additional parameters or definitions are required to reduce the variability in results?

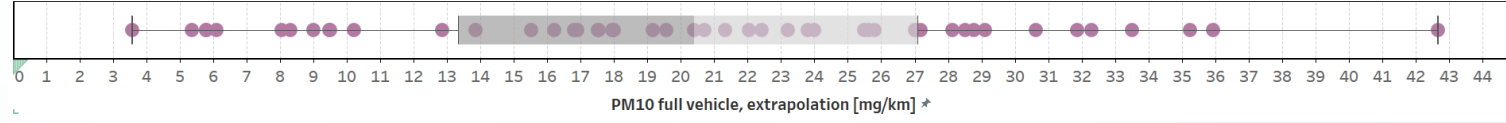
**First step:** establish a robust and repeatable setup & procedure for measurement (PMP GTR) for all vehicles and all (new) brake technologies

**Second step:** assess emission with current vehicles/braking technology for passenger cars and LCVs applying the PMP GTR





# ACEA BRAKE WEAR MEASUREMENT CAMPAIGN

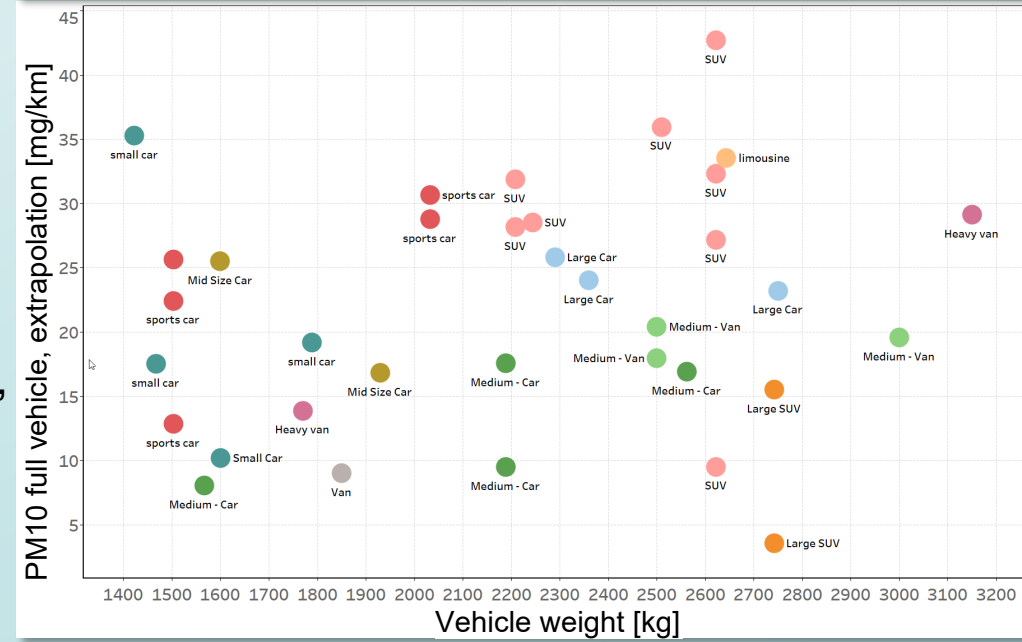
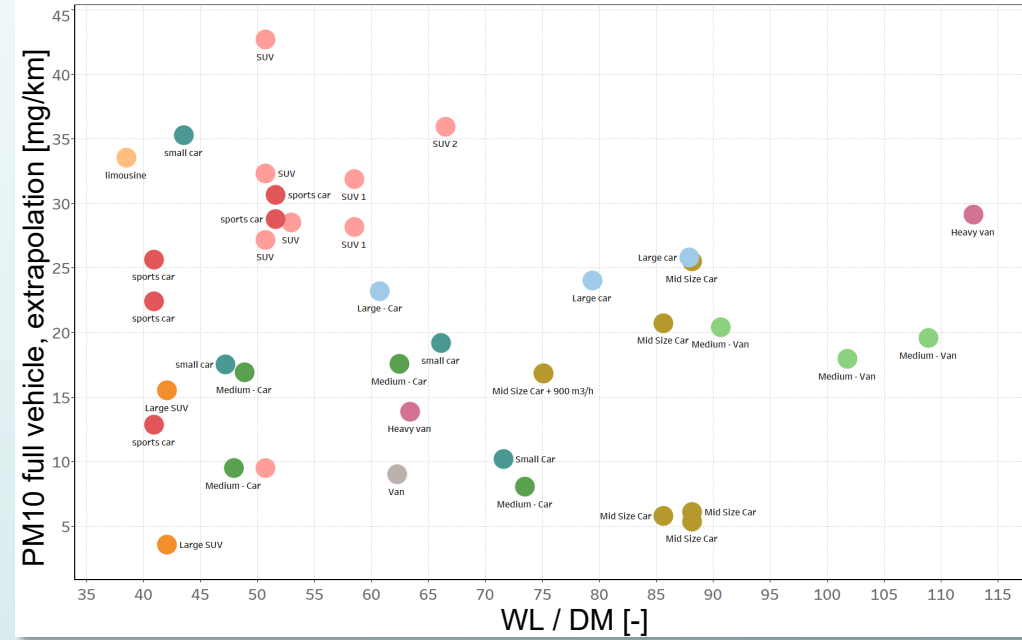


- ACEA Measurement campaign (in addition to PMP ILS)** for conventional series brake according to PMP measurement protocol shows a high variety of actual brake wear emissions<sup>1</sup> of
- up to 43 mg/km @PM10
  - With a mean at 20.4 mg/km (in sharp contrast to initial CLOVE data)
  - Without a clear correlation between the main reference variables (WL, Vehicle Weight, WL/DM...)



**Measurement campaign of ACEA (in addition to PMP ILS)** for conventional series brakes data show significant dispersion, independent of vehicle characteristics like weight or wheel load  
Can additional contributors be identified?

www.acea.auto <sup>1</sup> full-vehicle emission values are calculated from single brake results as 3 x front axle or 6 x rear axle.





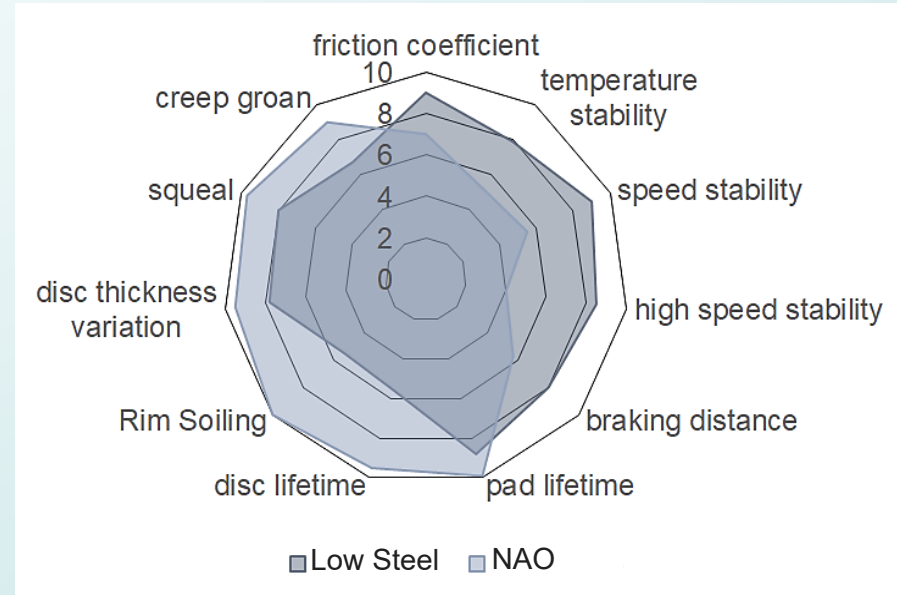
# POSSIBLE EMISSION REDUCTION POTENTIAL

- **CLOVE-assumed reduction potential** can
  - neither be confirmed by automotive industry
  - nor is new technology ready for mass market
- A variety of different aspects has to be fulfilled simultaneously
- Additional aspects need to be evaluated:  
eg. brake fade, weight/CO<sub>2</sub>, durability, costs, service intervals, power demand during operation, ...



**With the previously shown deviations, which cannot be attributed clearly:**

How should technical measures be evaluated & checked (homologation, press, NGOs, ...), if the measured emission results vary that much?



Source: ATZ 112 (2010), issue 5, pp. 352–357

- Brake pad material depends on the market.
- Low Steel brake pads are common in Europe.
- Different markets have different requirements.

Source: ACEA, 10<sup>th</sup> AGVES Meeting, April 27<sup>th</sup> 2021

**Third step:** assess impact of possible emission reductions (by PMP) on market requirements, brake fade, marketability, mass market industrialization, costs, aftersales, etc.





# MEASUREMENT PROCEDURE FOR REGENERATIVE BRAKING

## PMP TF4 is addressing regenerative braking

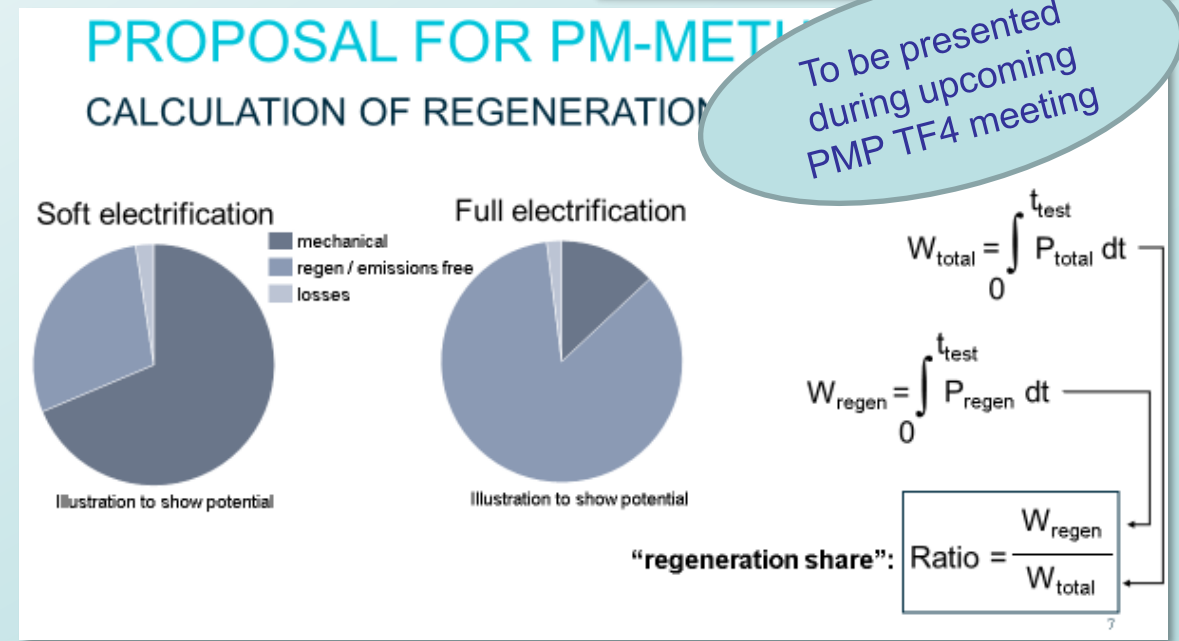
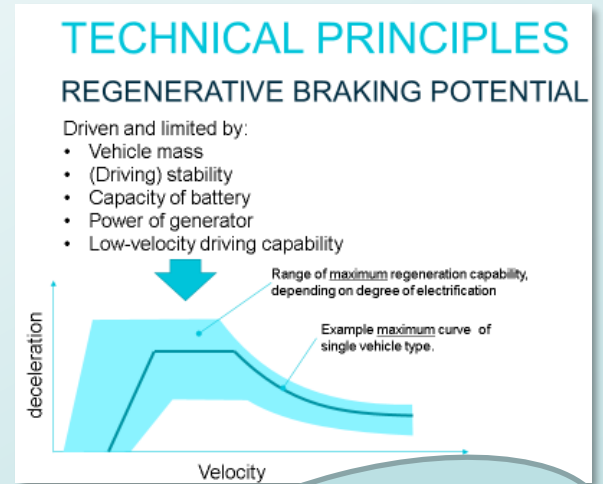
- **Powertrain electrification (and other methods)** show promising brake emission reduction potential
- But **measurement procedure** for emission free braking is **not yet available**
- ACEA strongly supports PMP TF4 to address **low-emission braking strategies** (to be presented in PMP on 2 Dec 2021)

## PMP TF4 has to be continued intensively.

“TF4 method” and “simplified method” have to be robustly prepared

Measurement data of some representative vehicles and brake systems needs to be collected to compare the methods

- Assuming good agreement, the simplified method could replace the more comprehensive TF4 method
- However, it has to be clarified if an OEM “declaration of conformity” for the emission level is required
- A simple approach is needed to determine the ratio  $W_{\text{regen}}/W_{\text{total}}$  by third parties





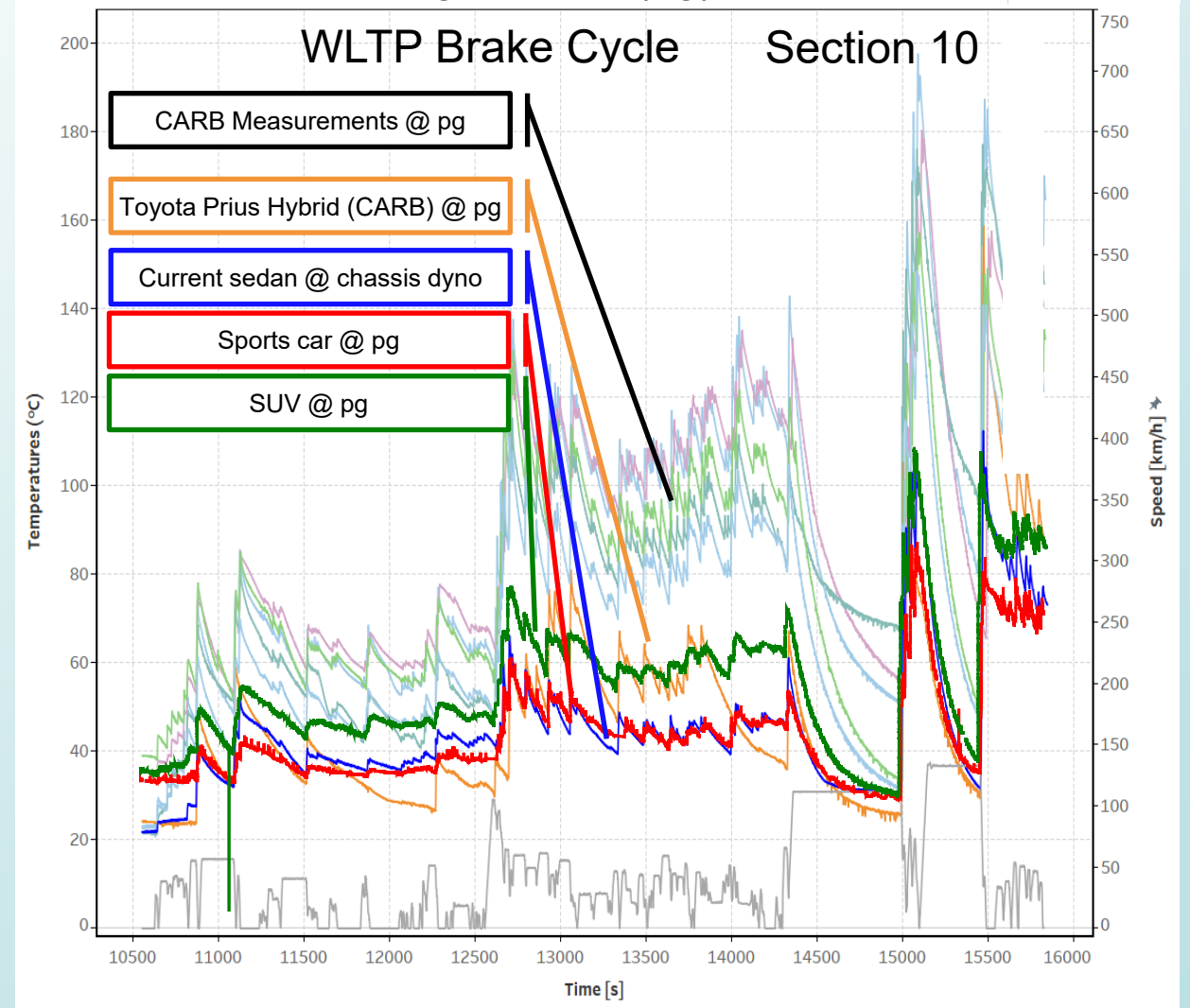
# TEMPERATURE RESULTS OF COMPLEX PROVING GROUND MEASUREMENTS

- Light colours: CARB measurements (supplied by TF2) @ proving ground (pg)
- Orange: Hybrid (Prius) @ pg
- Blue: current ICE vehicle (sedan) @ full vehicle exhaust emission dyno  
→ Temperature of ICE vehicle already at Hybrid level
- New data of 2 vehicles @ pg available
  - red: Sportscar (WL/DM = 47)
  - green: SUV (WL/DM = 57)

Temperature results significantly lower than known CARB Data

➔ **new input for PMP TF2.**  
**temperature limits to be reconsidered**

## Proving Ground (pg) Results

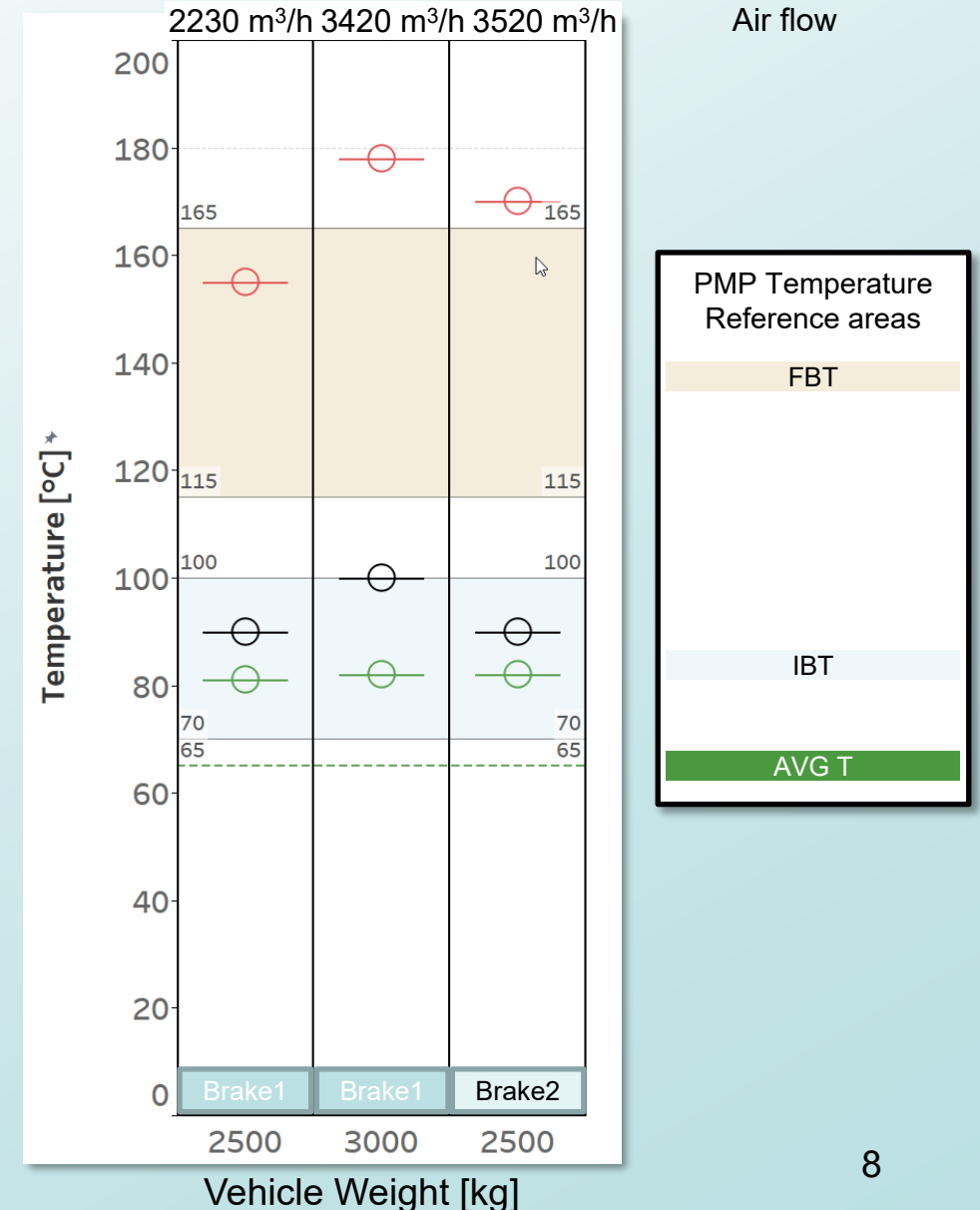




# LIGHT COMMERCIAL VEHICLE ISSUES (VANS)

## TEMPERATURE ISSUES

- Difficult to reach the given temperature ranges especially for high vehicle loads
- If a very high volume flow must be chosen to reach the given temperature limits → sampling might be not be correct
- Which **test weight** to be used during measurement?
- Which **temperature** to be used as PMP temperature reference?

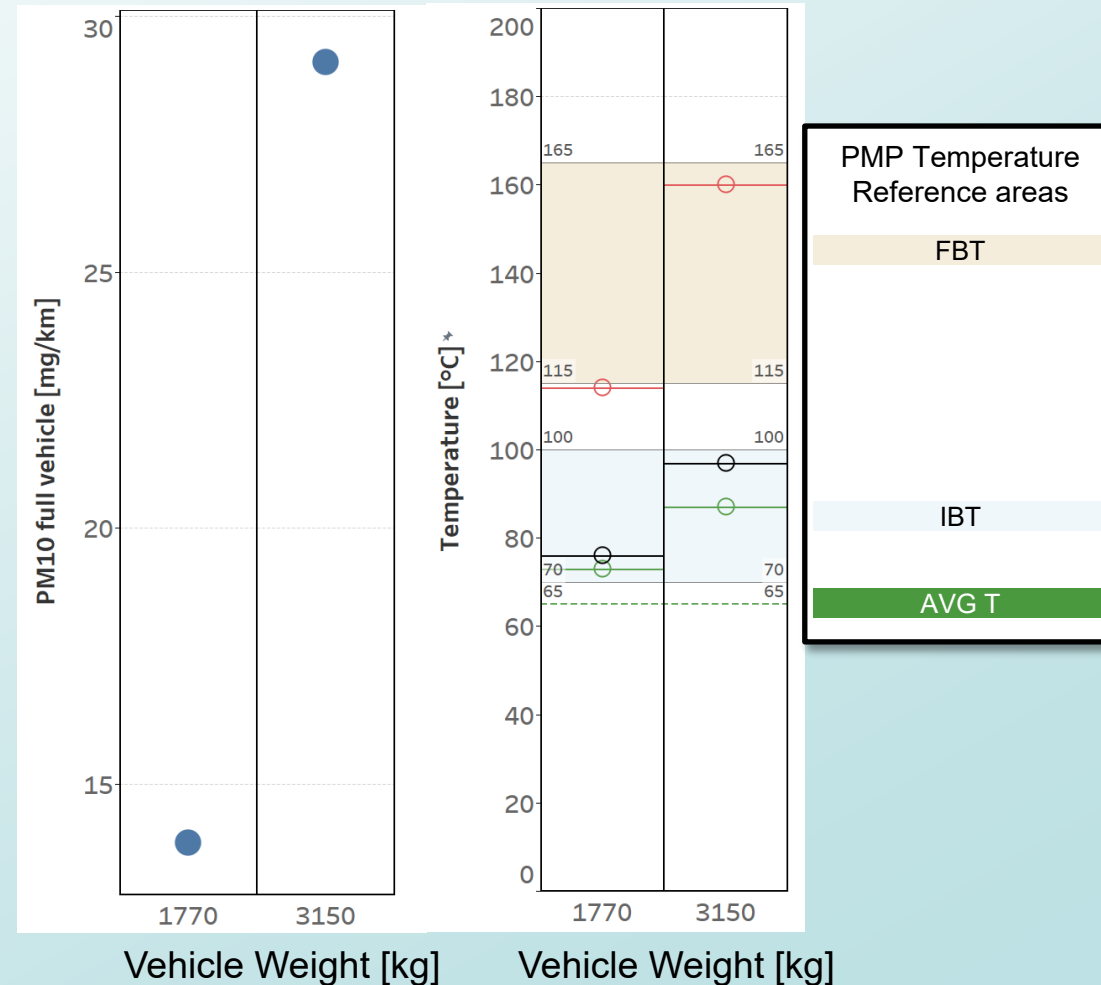




# ① LIGHT COMMERCIAL VEHICLES (VAN)

## TEST WEIGHT INFLUENCE

- Two tests run at two different payloads:
  - 1.5 passengers (PMP for passenger cars)
  - 90% GVW (loaded LCV)
- Both tests run at the same cooling settings
- PM data (factor 2.1 increase)
  - 1770 kg: 13.9 mg/km
  - 3150 kg: 29.1 mg/km
- Which **test weight** to be used as PMP reference for LCV?



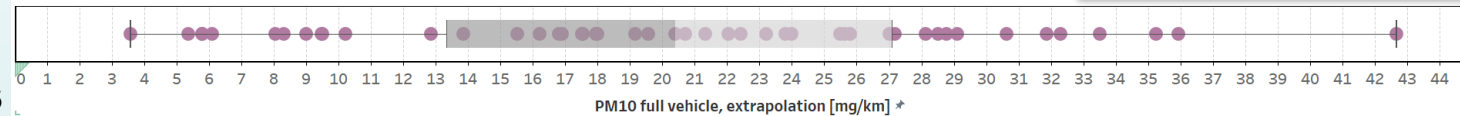


# BRAKE EMISSIONS – MOST IMPORTANT ISSUE

1. **Particle measurement differences:** Intermediate results of interlaboratory ACEA experiments  
For identical brakes: high differences in emissions results (factor 1.5 ... 2).

- ▶ **First step:** establish a robust and repeatable setup & procedure for measurement (PMP GTR) for all vehicles and all (new) brake technologies.
- ▶ **Second step:** assess emission with current vehicles/braking technology for passenger cars and LCVs applying the PMP GTR.

2. **Measurement campaign of ACEA** shows current brake wear emissions up to 43 mg/km @PM10 mean at 20.4 mg/km (contrast to CLOVE data



3. **Reduction potential of CLOVE-assumptions** can neither be confirmed by automotive industry nor is all technology ready for EU mass market

- ▶ **Third step:** assess impact of possible emission reductions (by PMP) on market requirements, eg. brake fade, marketability, mass market industrialization, costs, aftersales, etc.

4. **Measurement procedure for regenerative braking:** is not available, expert group TF4 is in its infancy.  
With continued electrification: vehicles in EU have vehicle energy regen. with a brake emission reduction potential

5. **Test procedure boundaries – Brake Temperature:** Temperature results at brake component test stands & at proving ground lower than assumed “typical” temperatures of PMP / CARB-Measurement campaign.

6. **LCV test specifications** needed: Temperature limits and vehicle weight → own TF-LCV required?

**Proposal: Extra workshop for brake emission issues. ACEA would be happy to share the existing knowledge and data**