RDE MEASUREMENTS OF A GDI WITHOUT AND WITH A GPF

J. Demuynck, C. Favre, D. Bosteels; AECC

H. Hamje; Concawe

J. Andersson; Ricardo Consulting Engineers Ltd.

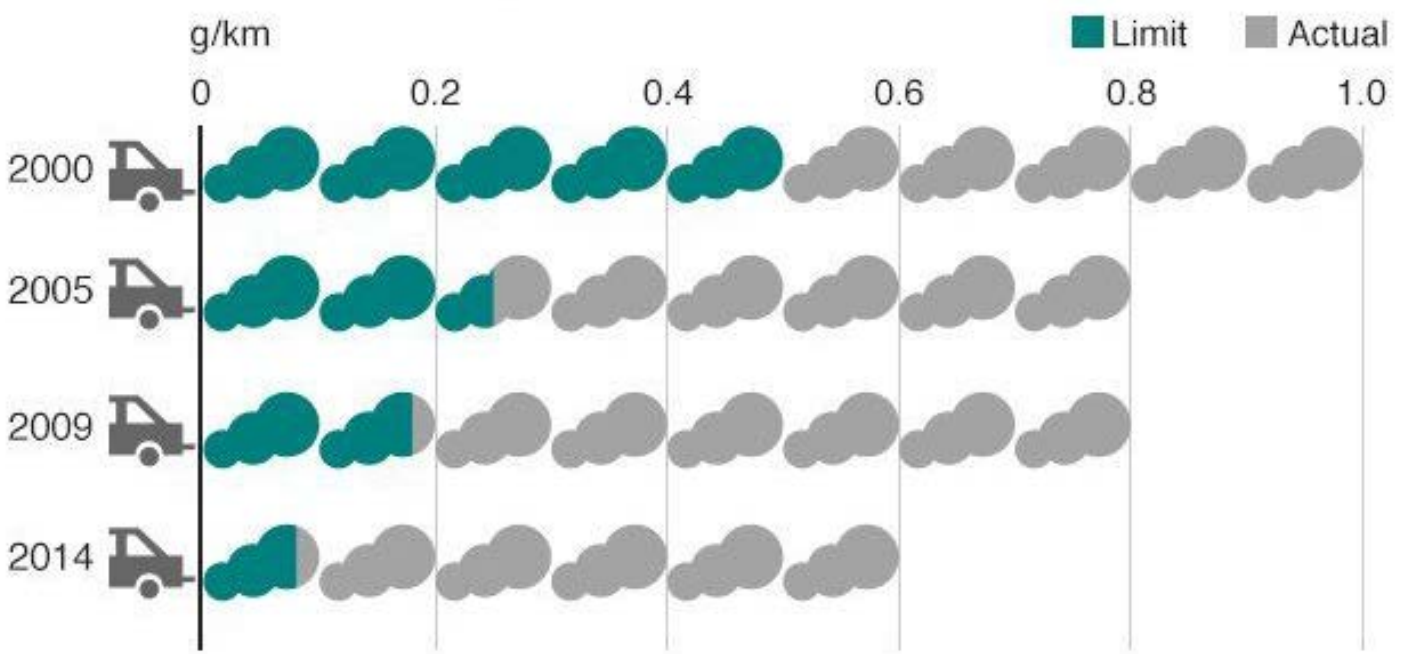
SAE INTERNATIONAL

AECC ASSOCIATION FOR EMISSIONS CONTROL BY CATALYST

concawe ENVIRONMENTAL SCIENCE FOR THE EUROPEAN REFINING INDUSTRY

RICARDO

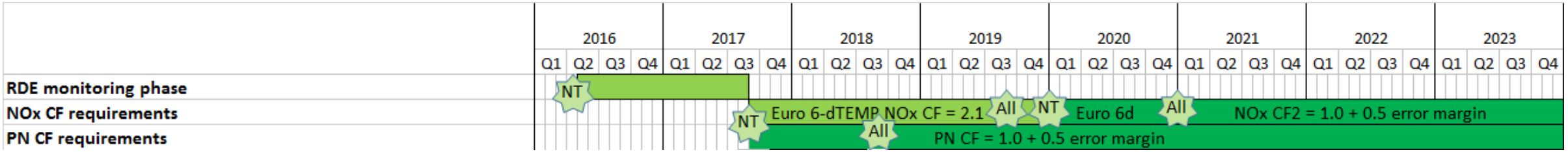
EU RDE legislation to close the gap between lab and real-world emissions



Source: the ICCT

EU RDE legislation to close the gap between lab and real-world emissions

- Not To Exceed limit (NTE) = Euro 6 limit x Conformity Factor (CF)
  - CF defined for NOx and PN
  - CF applies to urban part and total trip

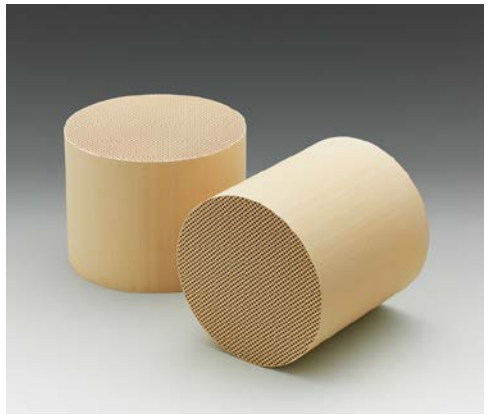


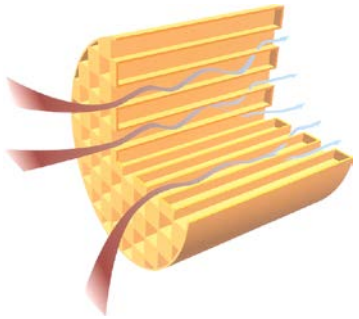
- RDE boundary conditions define normal driving
  - Route specifications
  - Ambient conditions
  - Driving dynamics
- RDE legislation being finalised

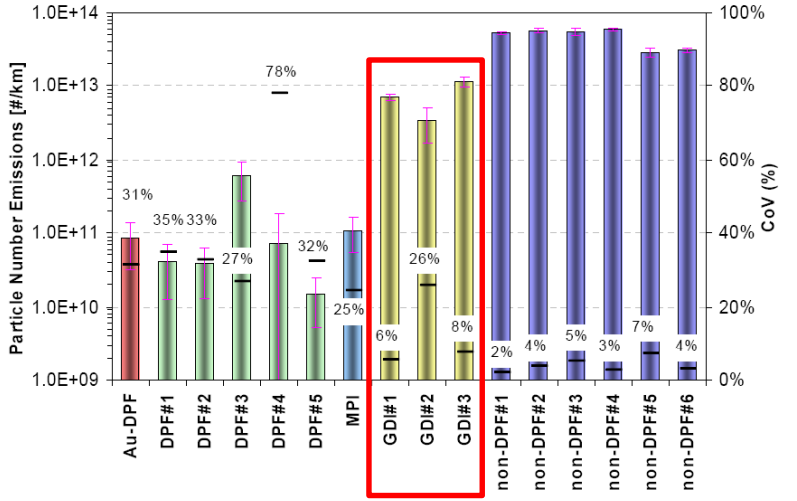
NTE: Not To Exceed
CF: Conformity Factor
NT: New Type Approval
All: All new vehicles

The GDI particle RDE issue

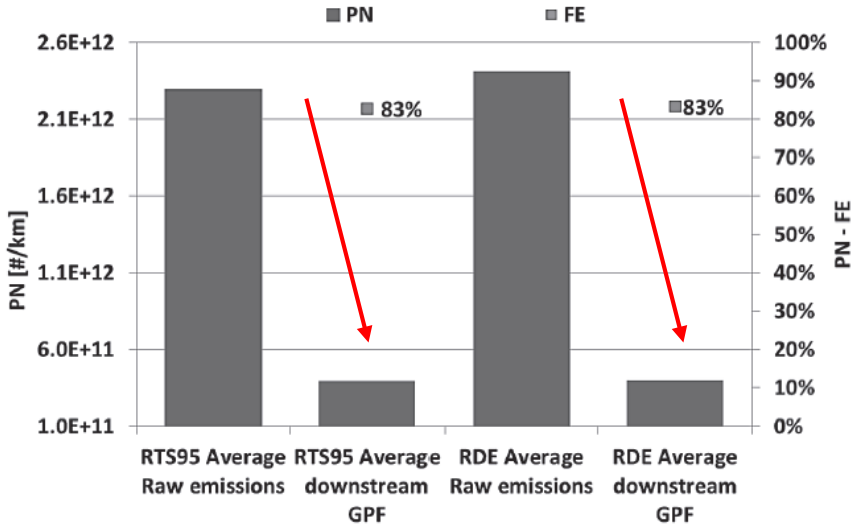
- CO_2 legislation promotes fuel-efficient Gasoline Direct Injection (GDI) in the EU
- Particles emitted by DI gasoline vehicles reported higher than Euro 6c limit of 6×10^{11} #/km, especially under real driving conditions
- Gasoline Particulate Filters (GPF) are an effective route to reduce the number of ultrafine particles under all driving conditions







Source: PMP Inter-Laboratory Correlation Exercise Final Report



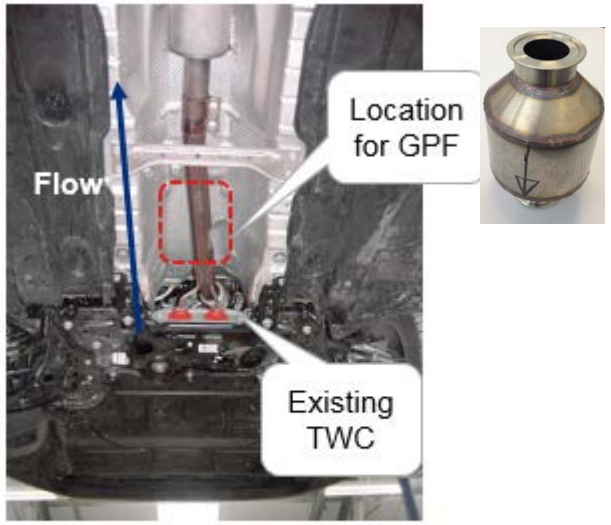
Source: AECC member

Content

- Test programme set-up
- Particulate emissions on regulatory test cycles (NEDC and WLTC)
- Real-Driving Particulate Emissions (RDE)
  - On the road
  - On the chassis dyno: impact of boundary conditions
- Conclusion

Test programme set-up

- Vehicle
  - C-segment, 1.4l engine
  - Market representative GDI technology; Euro 6b certified
  - Original configuration w/o GPF
  - Add coated GPF demonstrator underfloor
- HORIBA PEMS equipment
  - Gaseous PEMS (CO_2, CO, NOx)
  - PEMS-PN demo unit
- Parameters to evaluate
  - fuel type & quality
  - driving dynamics (RDE on dyno)
  - cold ambient temperature (RDE on dyno)
  - sub-23nm PN
- Test matrix



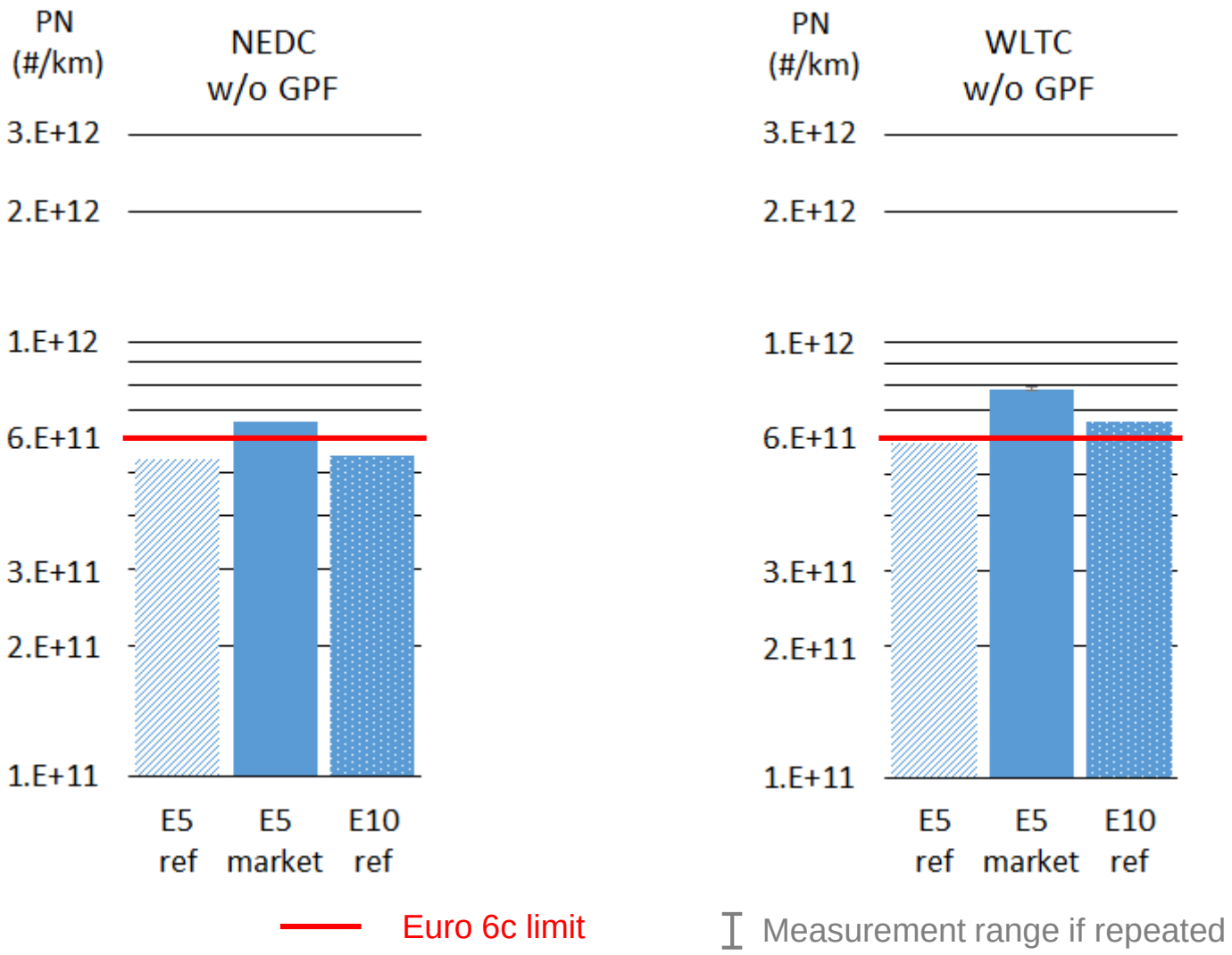
Underfloor view

Exhaust	Fuel	NEDC + WLTC	RDE on road	RDE on dyno
Original (without GPF)	Ref E5	1x	-	-
	Ref E10	1x	3x	-
	Market E5	1x	3x	6x
With coated GPF	Ref E10	1x	3x	-
	Market E5	1x	3x	6x

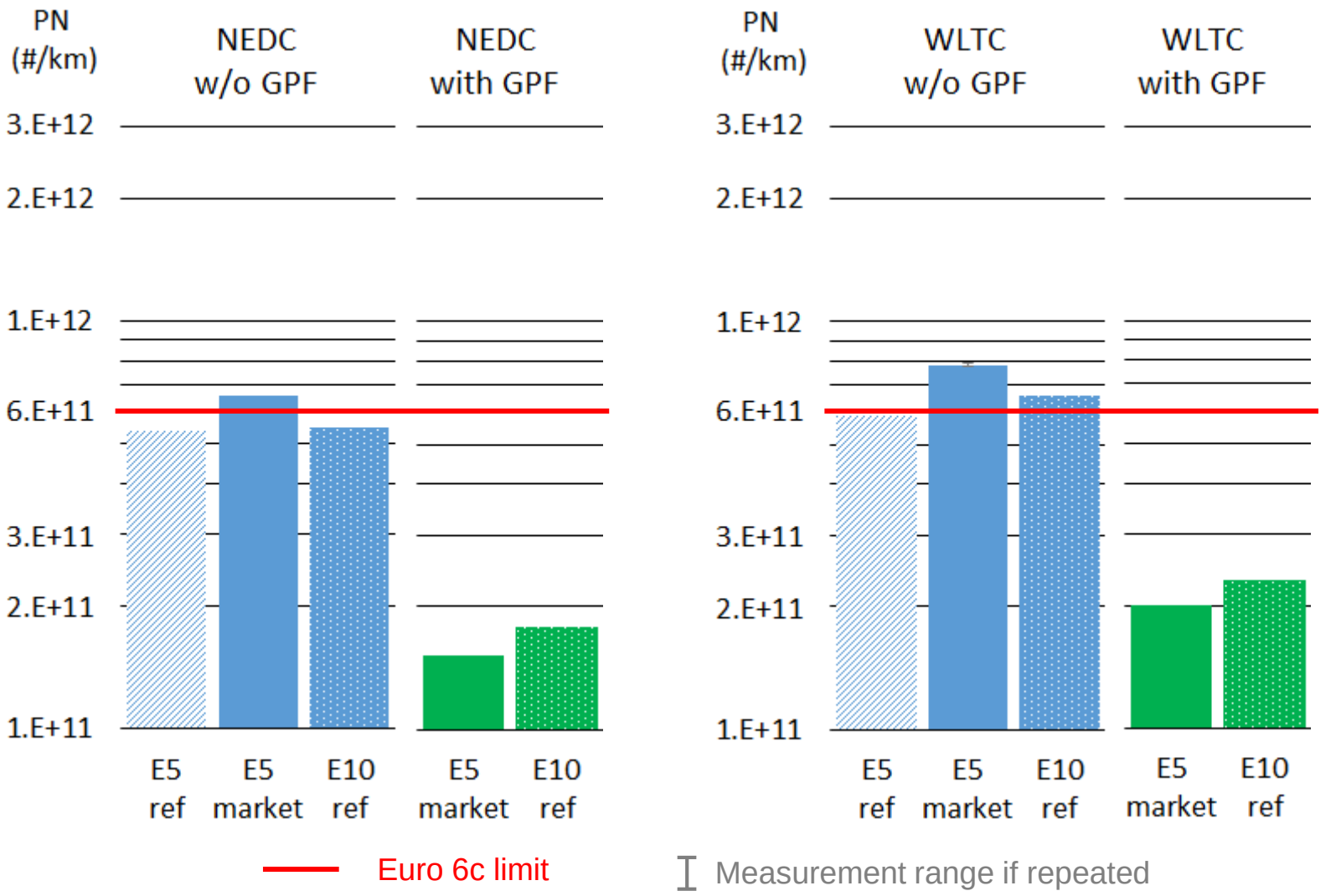
Content

- Test programme set-up
- Particulate emissions on regulatory test cycles (NEDC and WLTC)
- Real-Driving Particulate Emissions (RDE)
  - On the road
  - On the chassis dyno: impact of boundary conditions
- Conclusion

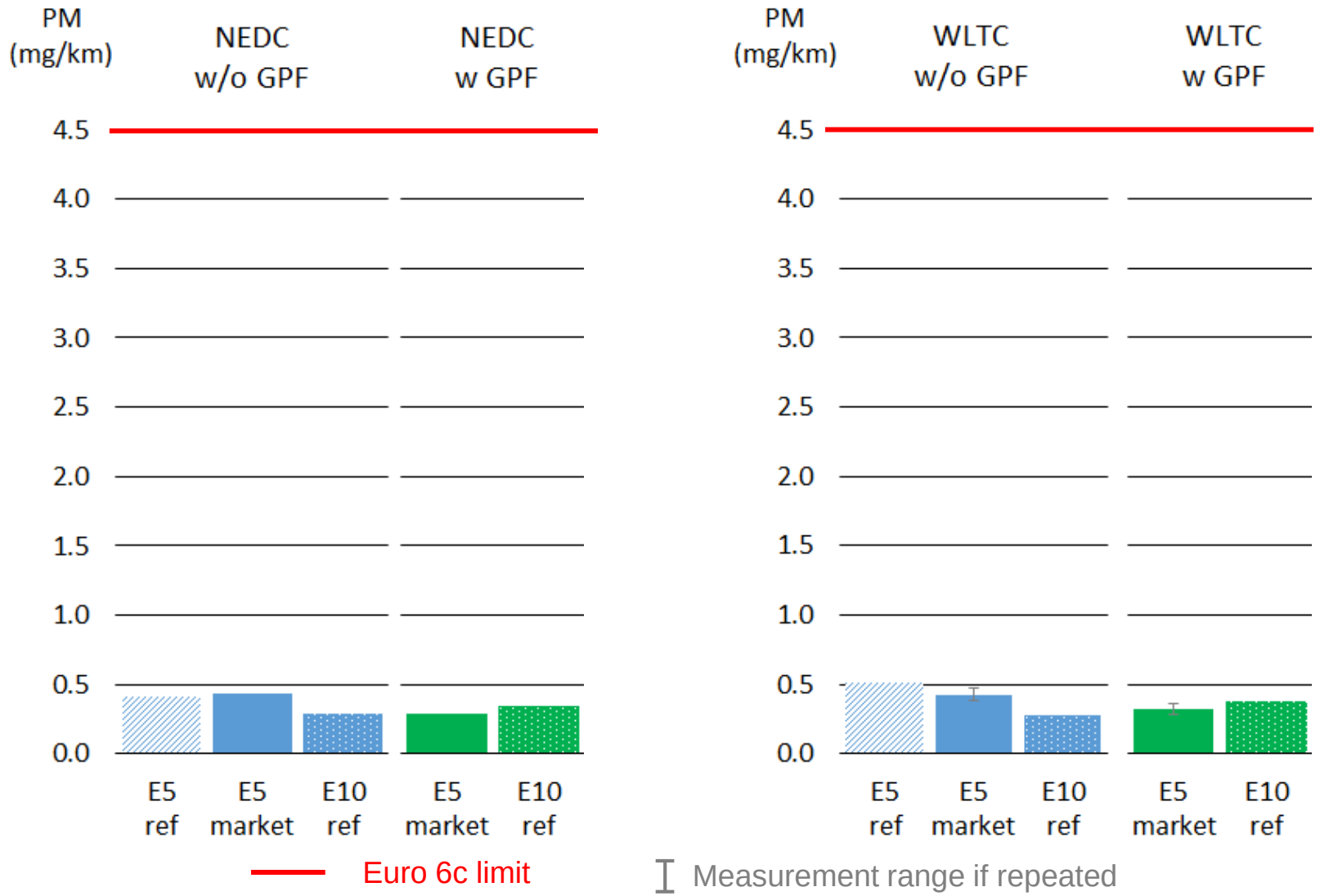
PN results w/o GPF are below Euro 6c limit on NEDC and WLTC with E5 ref fuel, but go above limit with other fuels



PN results with GPF stay below Euro 6c limit on NEDC and WLTC



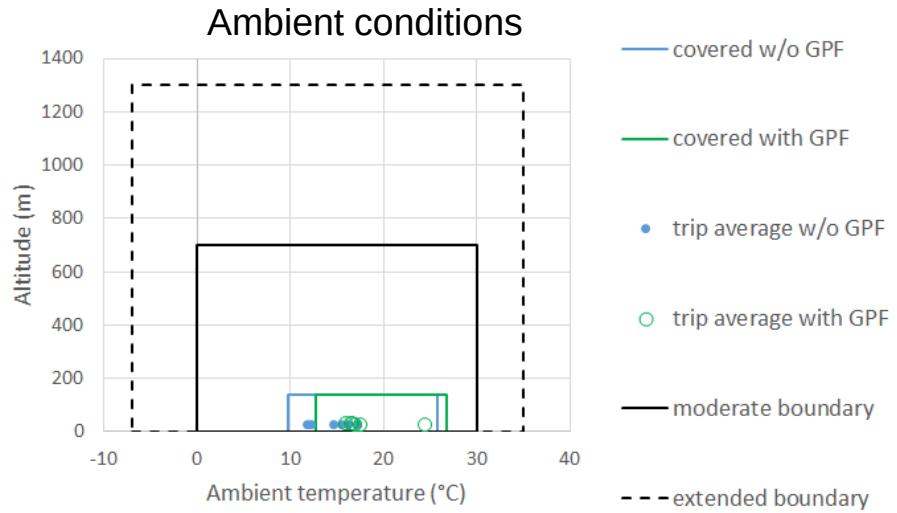
PM emissions are well below Euro 6c limit on NEDC and WLTC, no measurable difference between two vehicle configurations

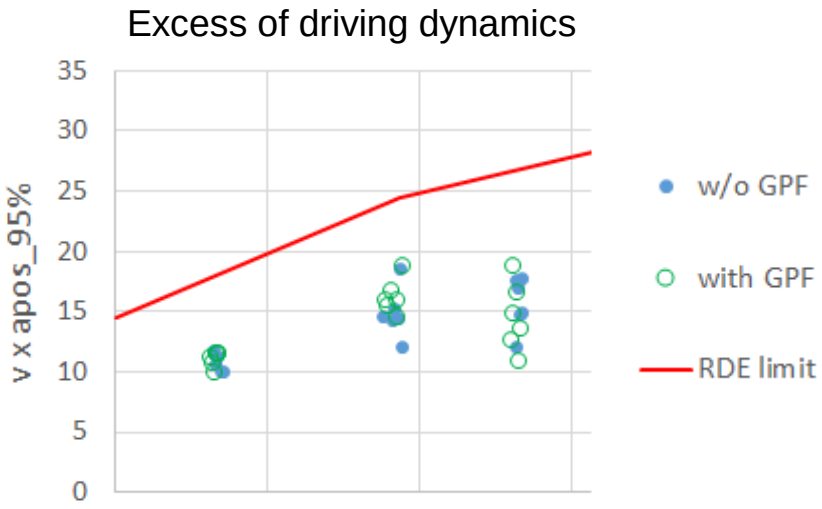


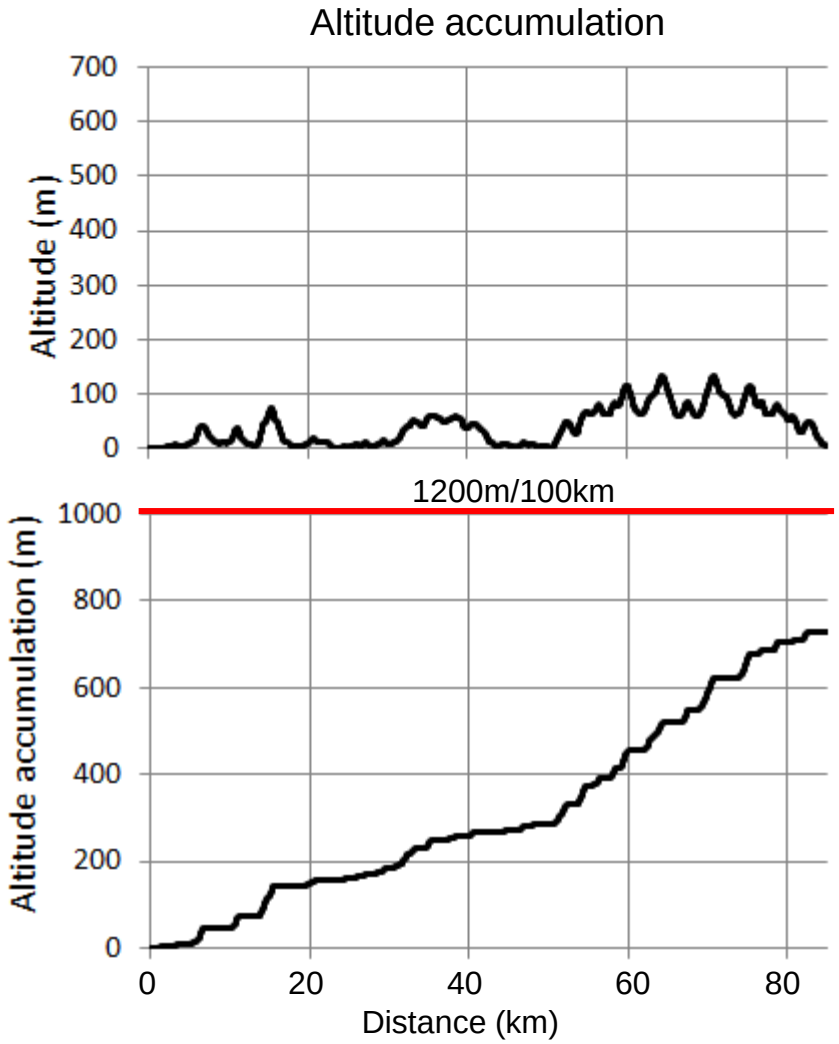
Content

- Test programme set-up
- Particulate emissions on regulatory test cycles (NEDC and WLTC)
- Real-Driving Particulate Emissions (RDE)
  - On the road
  - On the chassis dyno: impact of boundary conditions
- Conclusion

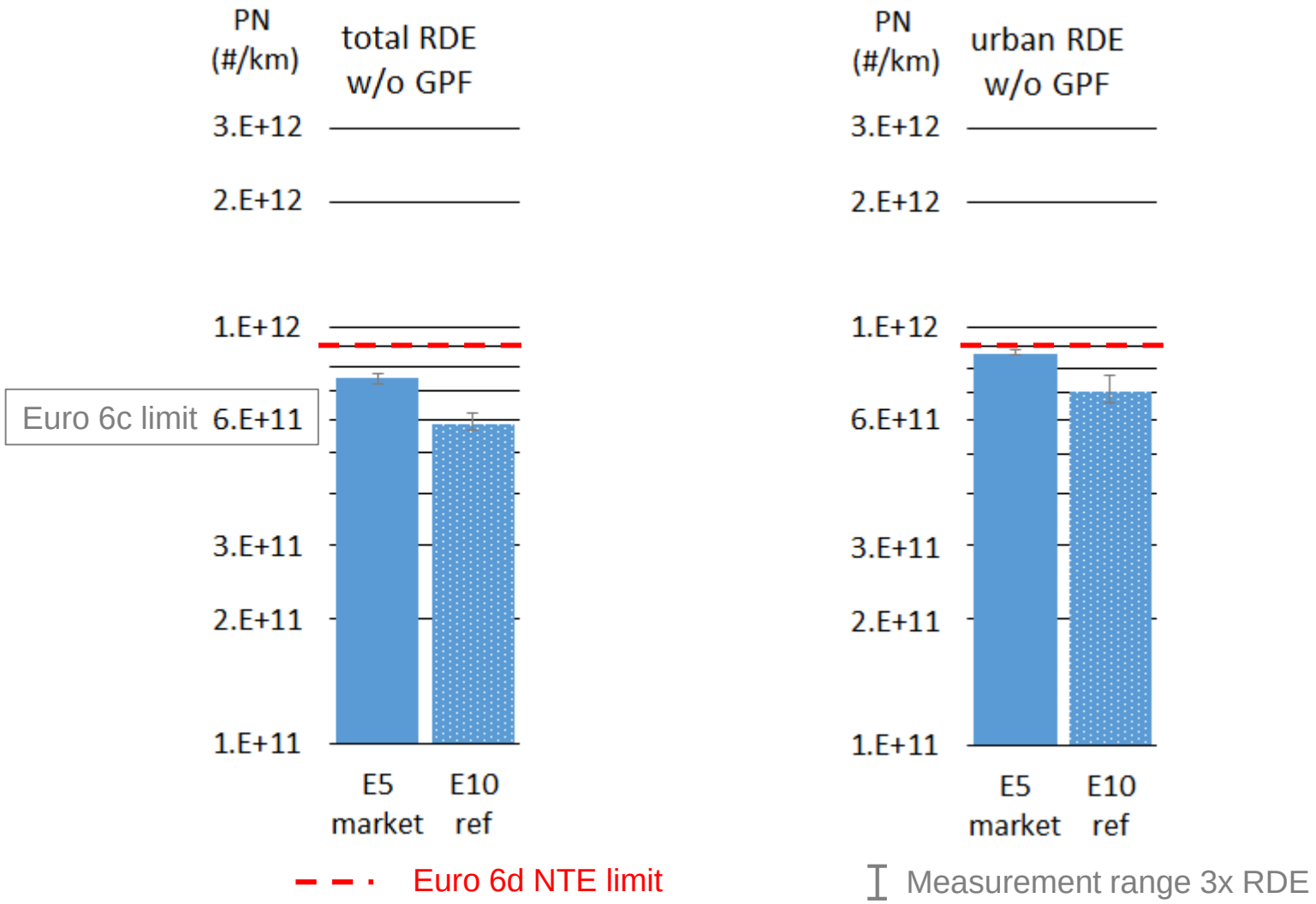
Measured data are within the RDE boundary conditions



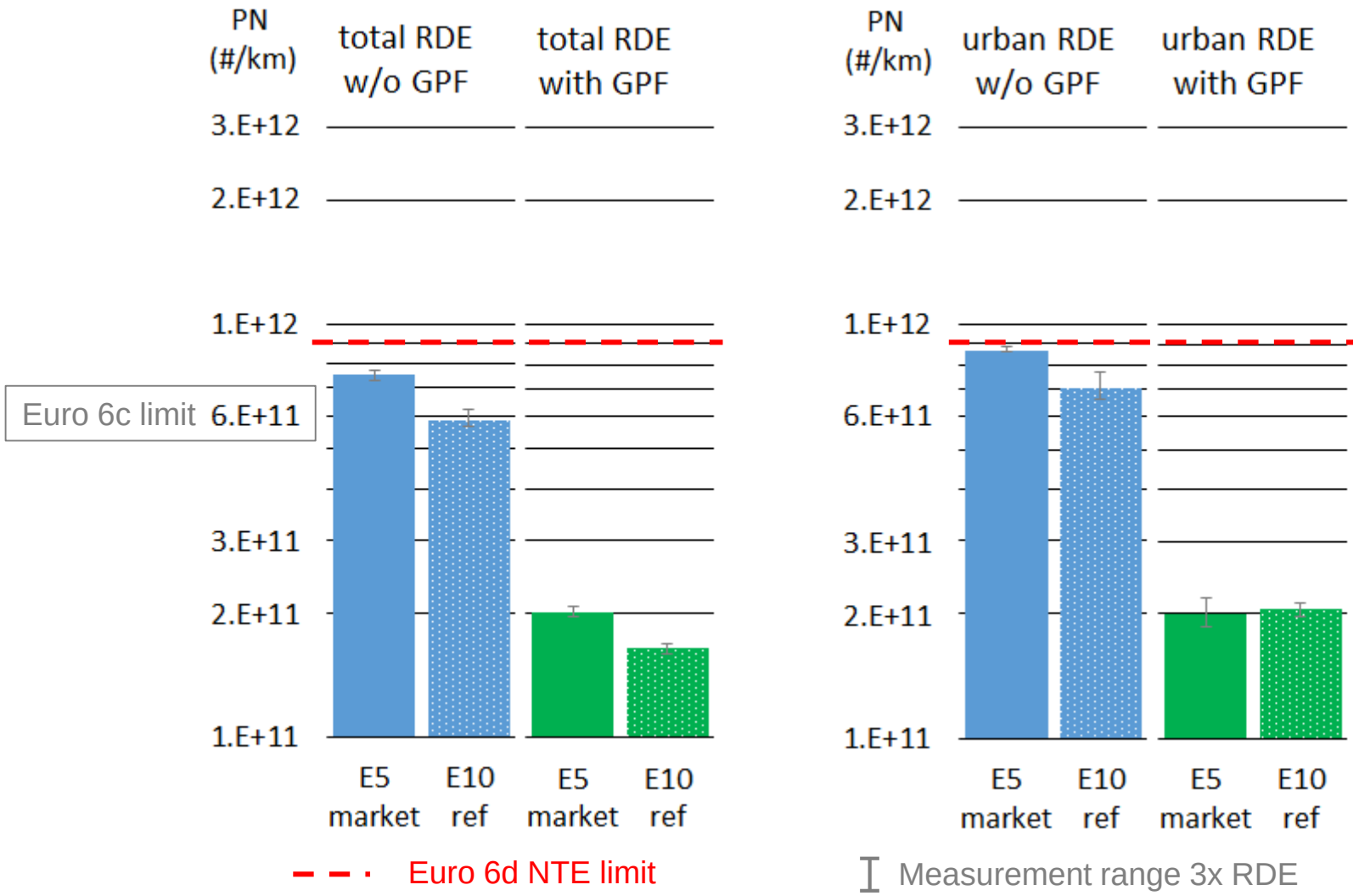




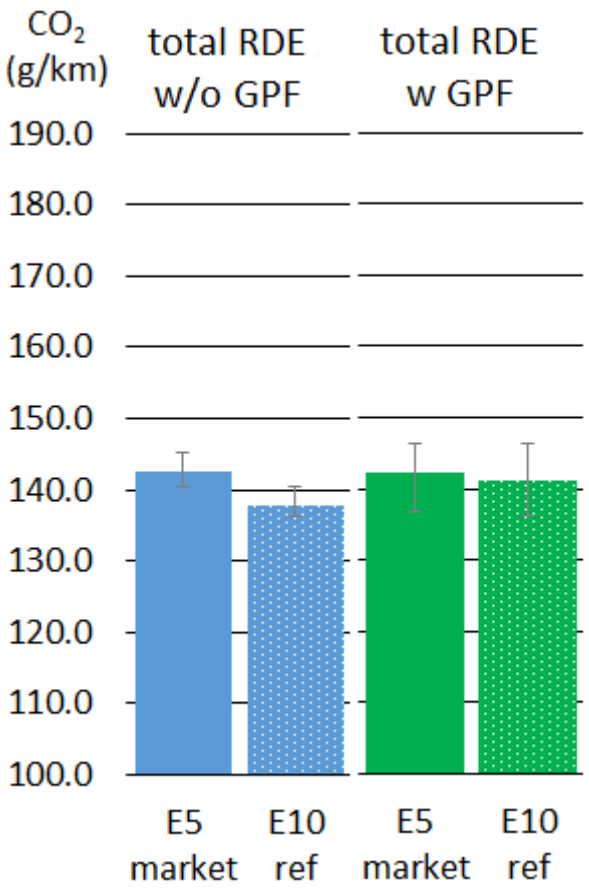
PN results w/o GPF increase towards Euro 6d NTE limit on the road

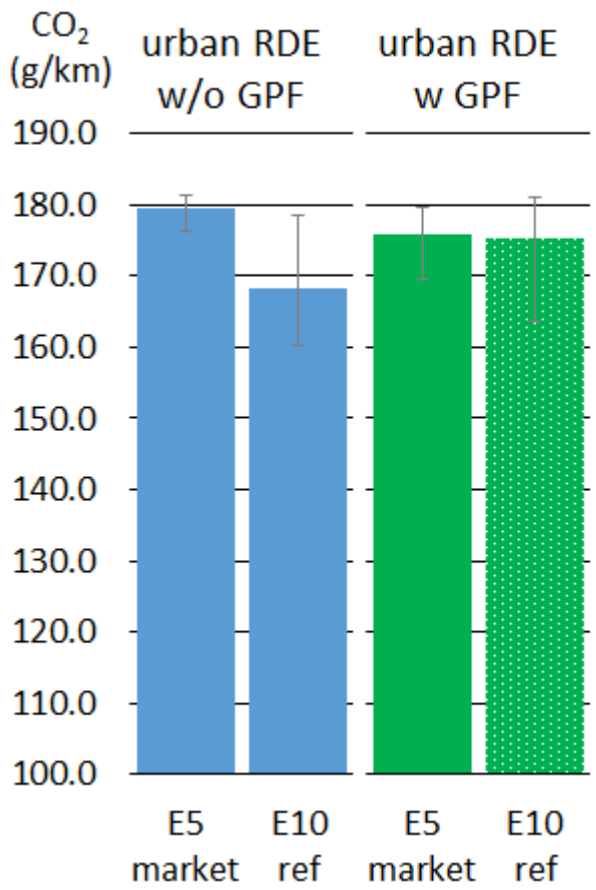


PN results with GPF are well below Euro 6d NTE limit on the road



No CO_2 penalty was measured for the GPF on the road





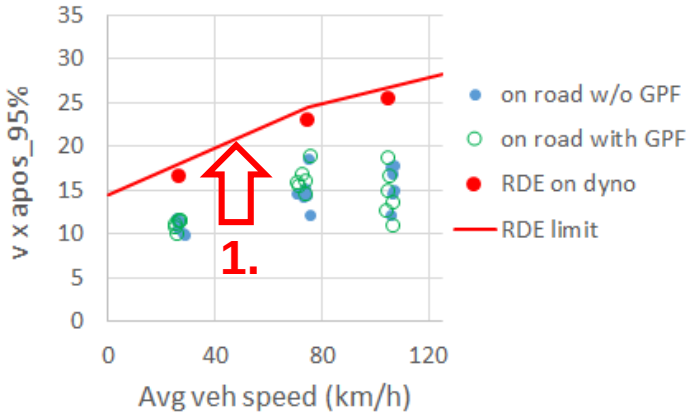
I Measurement range 3x RDE

Content

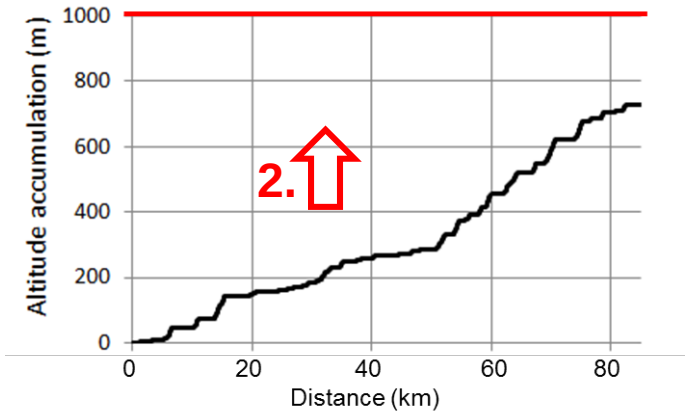
- Test programme set-up
- Particulate emissions on regulatory test cycles (NEDC and WLTC)
- Real-Driving Particulate Emissions (RDE)
  - On the road
  - On the chassis dyno: impact of boundary conditions
- Conclusion

RDE on dyno to investigate impact of going towards RDE boundary conditions

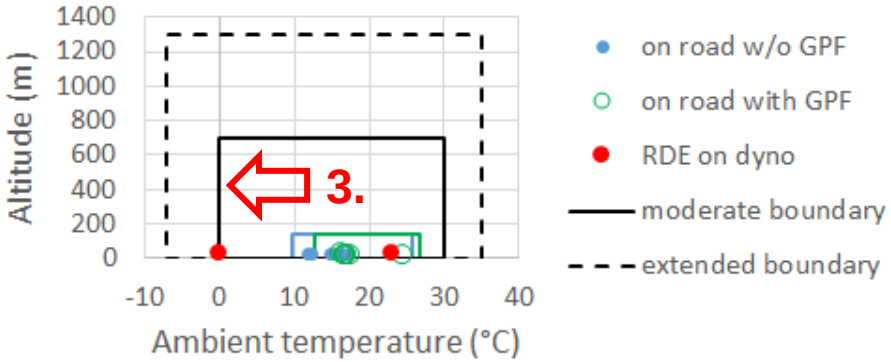
1. Change accelerations

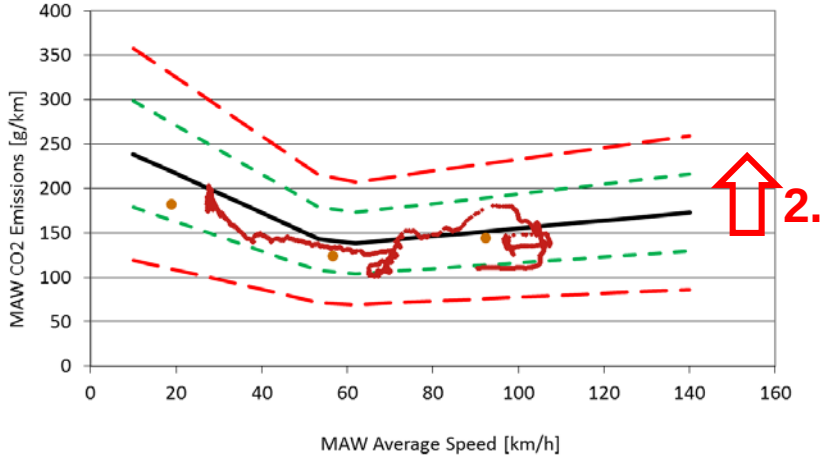


2. Change dyno load

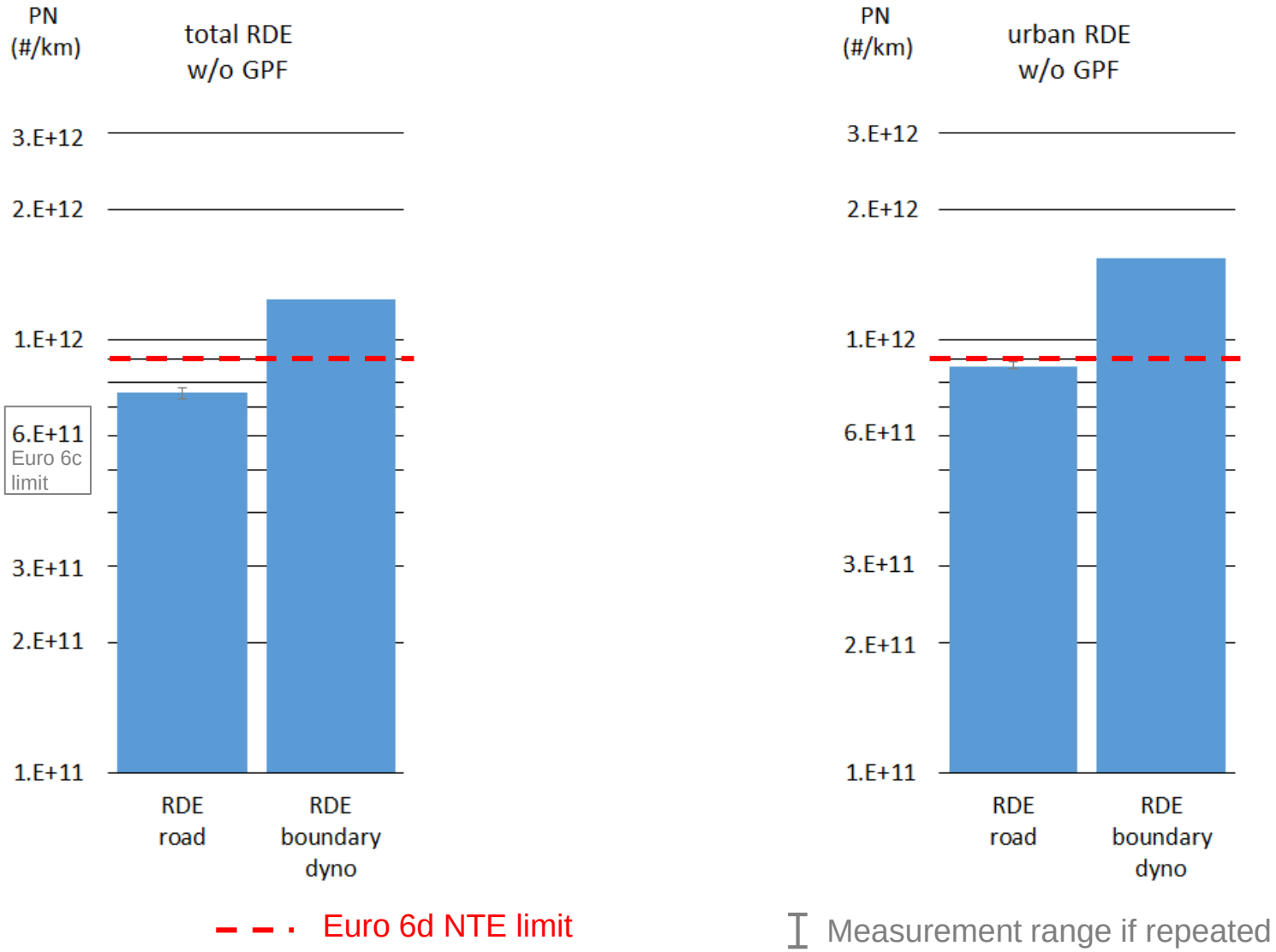


3. Change ambient temperature

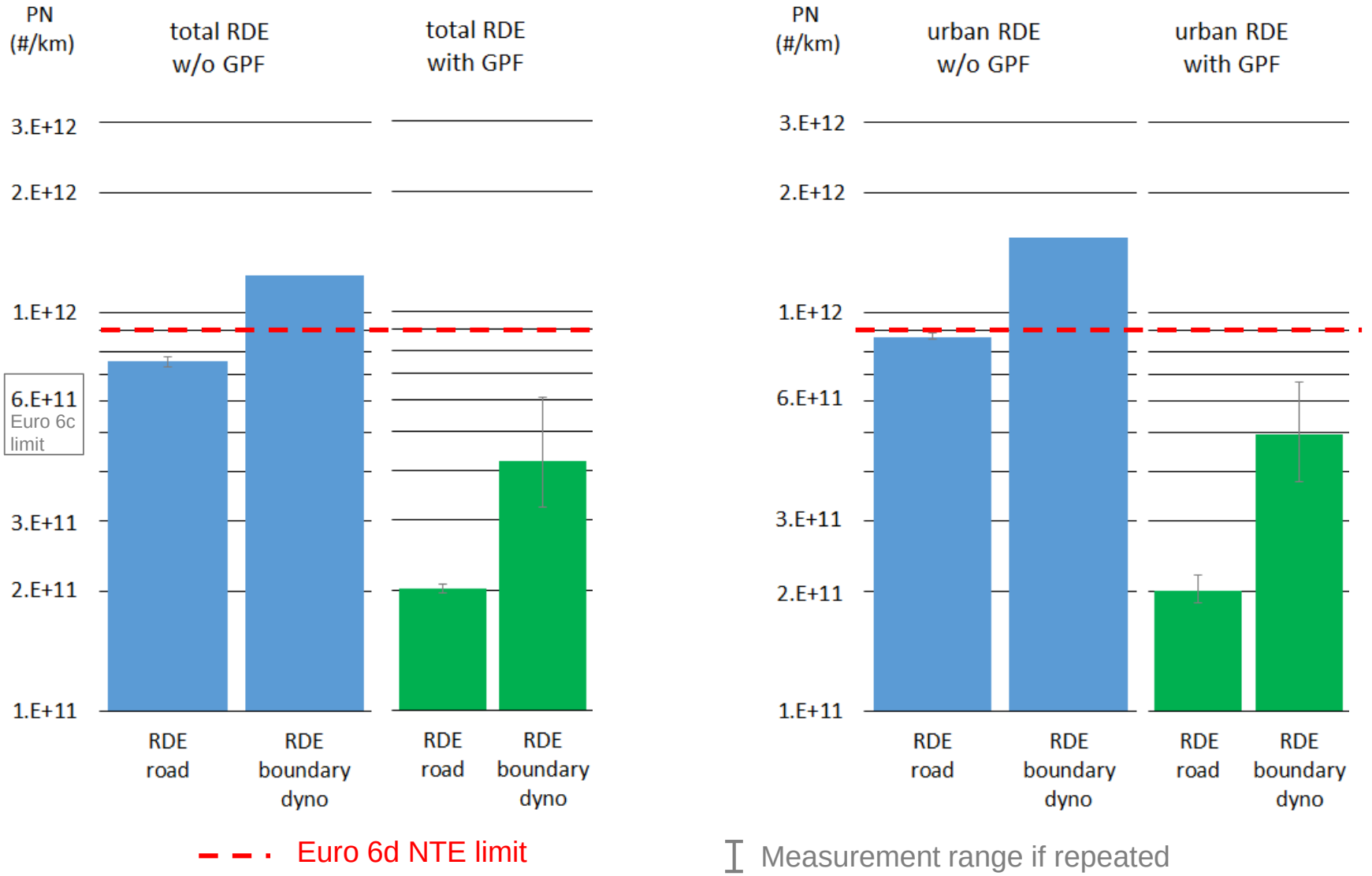




PN results w/o GPF increase above Euro 6d NTE limit towards RDE boundary conditions

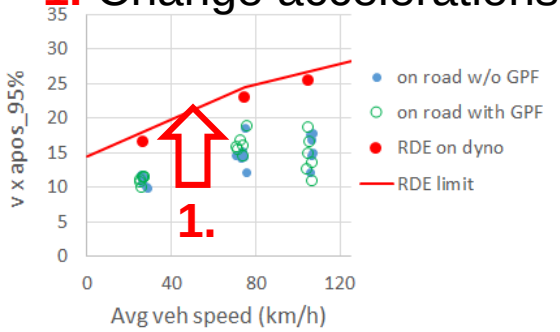


PN results with GPF remain below Euro 6d NTE limit towards RDE boundary conditions

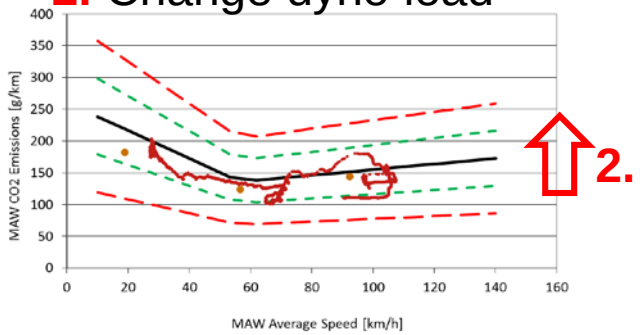


All PM results remain significantly below 4.5 mg/km towards RDE boundary conditions

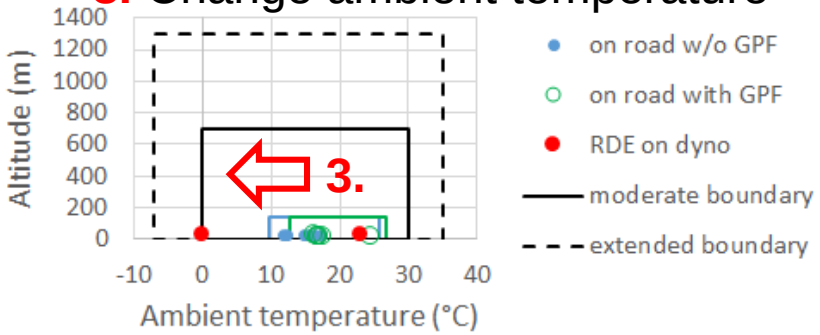
1. Change accelerations

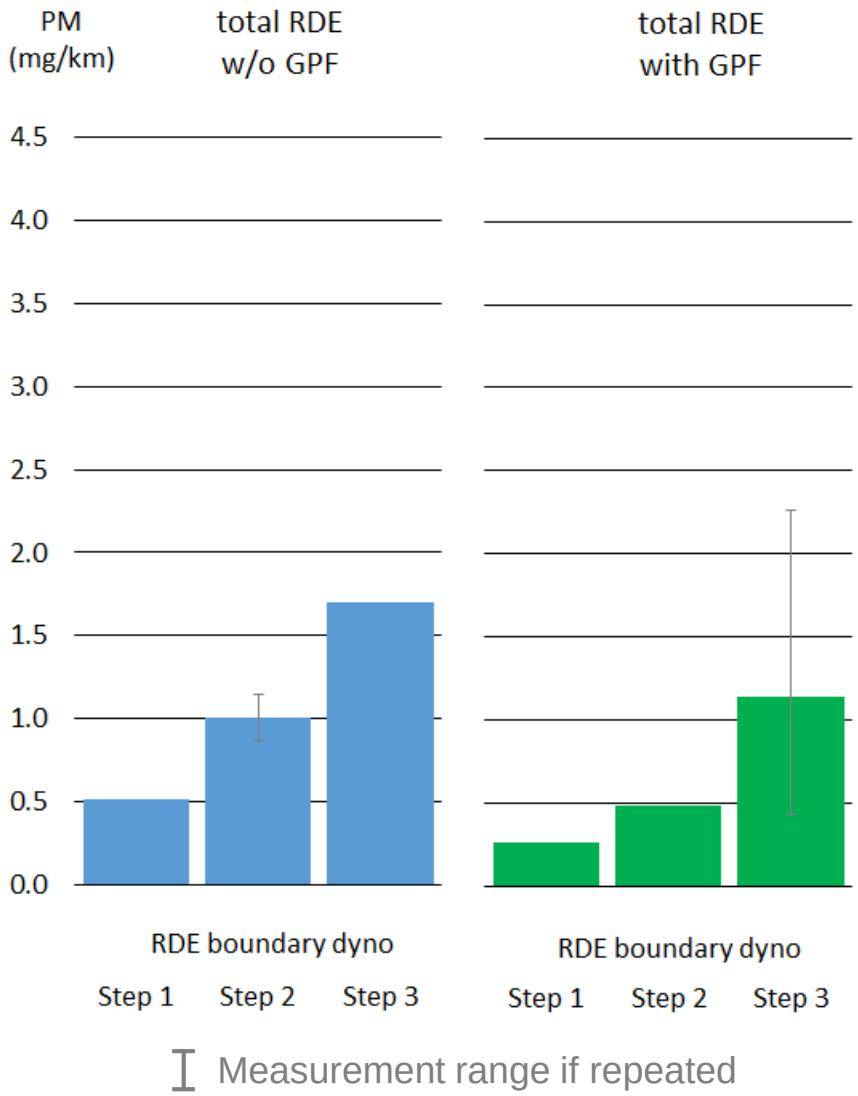


2. Change dyno load



3. Change ambient temperature



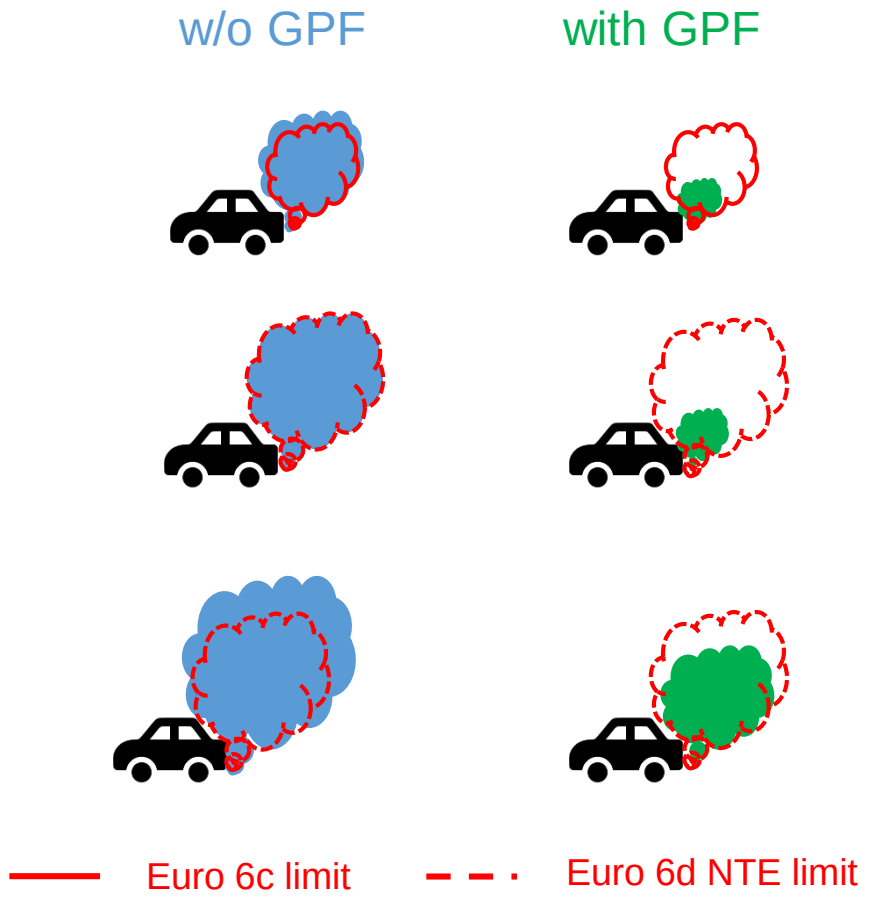


Content

- Test programme set-up
- Particulate emissions on regulatory test cycles (NEDC and WLTC)
- Real-Driving Particulate Emissions (RDE)
  - On the road
  - On the chassis dyno: impact of boundary conditions
- Conclusion

Conclusion

RDE PN emissions from a Euro 6b GDI vehicle were measured with and without a GPF



Thank you for your attention!

- Acknowledgements
  - AECC members for funding and supporting
  - Concawe for working in partnership
  - Ricardo for testing and data analysis

- Contact details
  - Joachim Demuynck
  - joachim.demuynck@aecc.eu
  - www.aecc.eu