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BRAKE PARTICLE EMISSIONS

TASK FORCE 1

DEVELOPMENT OF A NEW REAL-WORLD BRAKING CYCLE FOR STUDYING BRAKE PARTICLE EMISSIONS

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50th PMP IWG Meeting – Brussels (BE) – 04.04.2019

DEVELOPMENT OF A NOVEL BRAKING CYCLE FOR STUDYING BRAKE PARTICLE EMISSIONS

March 2015: The PMP identified the need either for the adoption of an existing cycle or the development of a novel cycle as an important step for the development of the commonly accepted methodology - A four steps approach was followed

- WLTP Database Analysis - Definition of "typical" and "extreme" driving/braking conditions (Concluded - March 2016 - Report available at <https://wiki.unece.org/display/trans/PMP+39th+session>)
- Comparison of WLTP statistics with those of existing braking cycles (i.e. LACT, Mojacar, AK Master) (Concluded - October 2016 - Report available at <https://wiki.unece.org/display/trans/PMP+41st+session>)

October 2016: Based on the results of Steps 1 & 2 the PMP decided that the development of a novel cycle which would be representative of real-world braking conditions would make more sense than the adoption of an existing one - A specific Task Force (TF1) within the PMP IWG was created

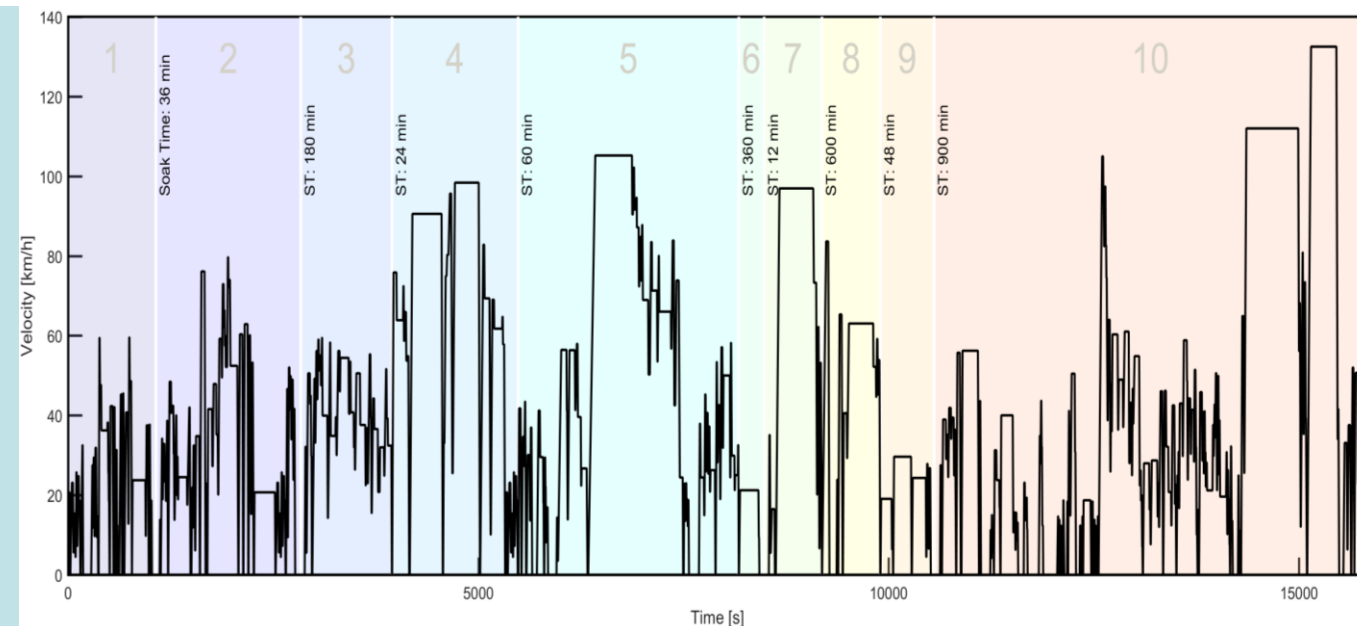
DEVELOPMENT OF A NOVEL BRAKING CYCLE FOR STUDYING BRAKE PARTICLE EMISSIONS

November 2016: TF1 started working on the development of the novel cycle and defined two major steps in order to complete the task

- Development of a first version of the novel braking cycle (Concluded - June 2018 - Cycle freely available at <https://data.mendeley.com/datasets/dkp376g3m8/1>)
- Validation of the novel cycle - Round robin with the aim of assessing its repeatability and reproducibility at the brake dyno level - (Concluded - March 2019 - <https://wiki.unece.org/display/trans/PMP+50th+Session> - Report to be submitted in June 2019)

Conclusion: The novel cycle seems to be repeatable and reproducible at dyno level. First results indicate that the cycle can replicate vehicle temperature regimes at a satisfactory level provided that a very well defined measurement protocol is followed

NOVEL BRAKING CYCLE

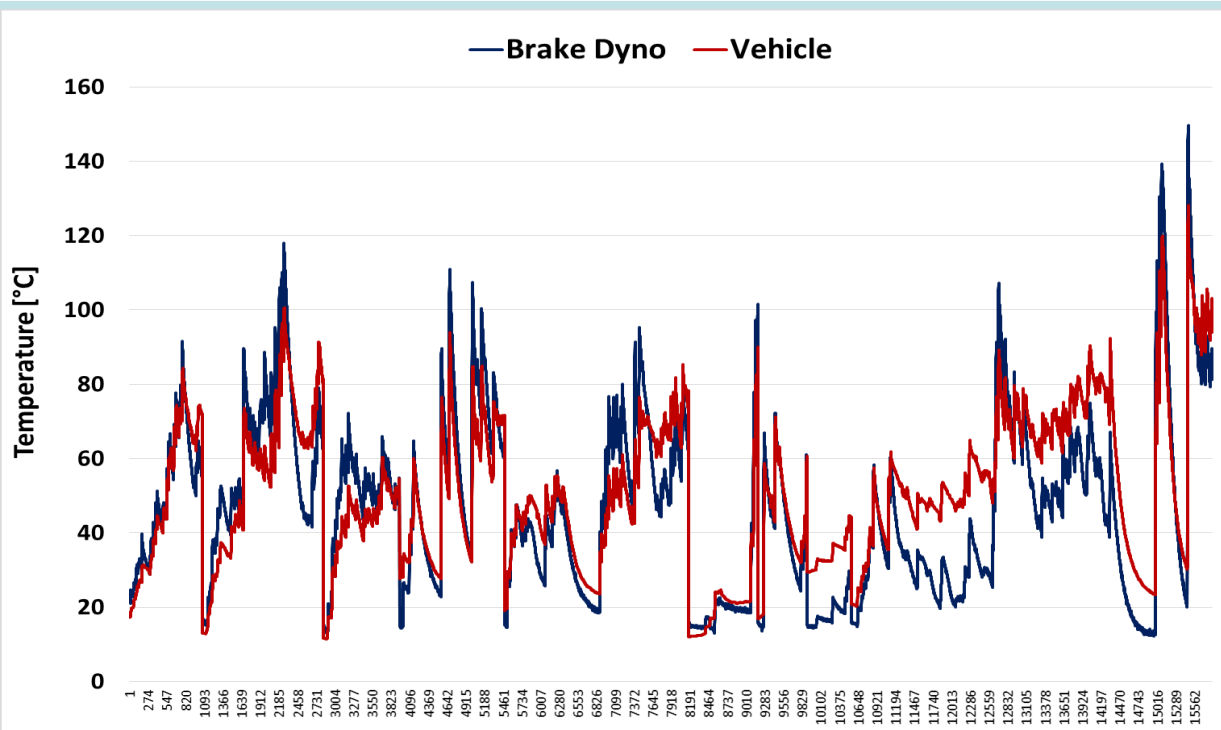
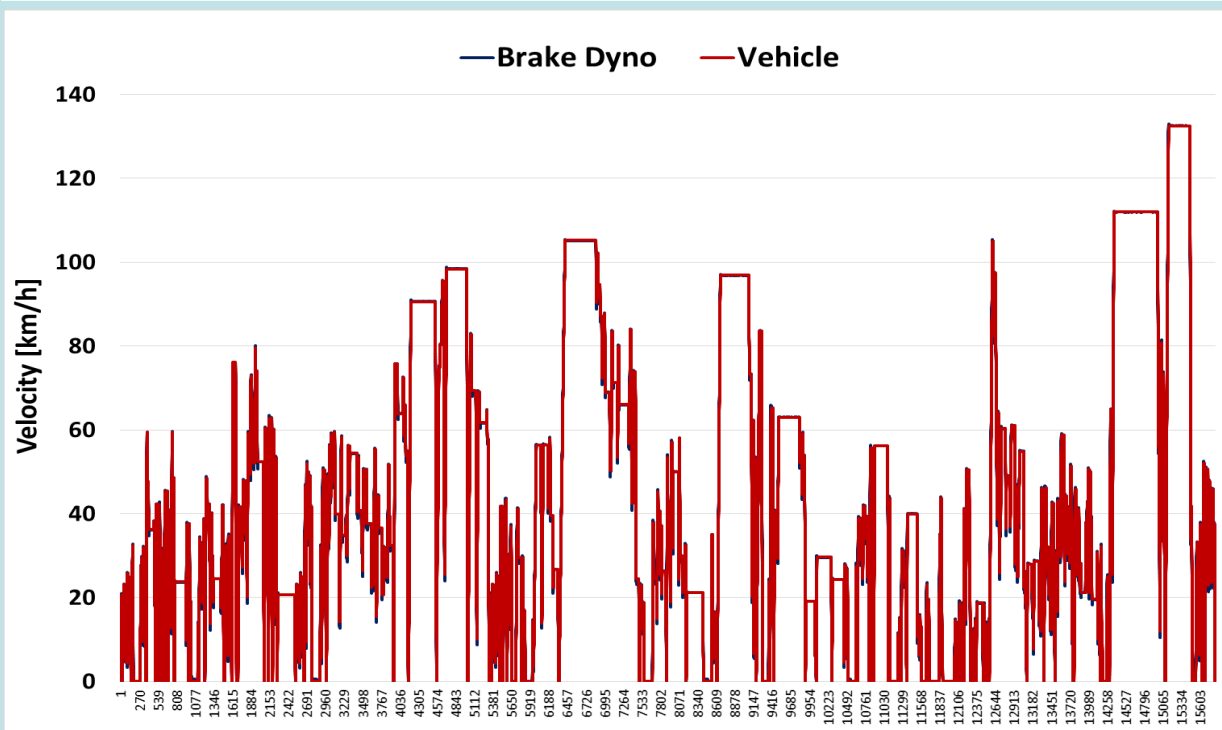


- 10 trips representing mixed urban, rural and motorway conditions (303 stops - 4½ h - 192 km)
- Average velocity of 43.7 km/h with max being 132.5 km/h (6% of the time speed > 110 km/h)
- Brake related deceleration rates of 0.5–2.2 m/s² (average 1.0 m/s² vs. ~0.9 m/s² of WLTP database)
- Soak times (time required after a trip for brake temperature to reach 20°C) vary significantly depending on various conditions

	1	2	3	4	5	6	7	8	9	10	All
Time [s]	1070	1765	1112	1537	2691	308	705	711	655	5272	15826
Stops [-]	29	42	28	18	49	2	6	8	7	114	303
Distance [km]	6.0	15.2	11.7	29.3	37.3	1.3	13.5	9.2	3.9	64.8	192
Velocity [km/h]	20.2	31	37.9	68.6	49.8	16.2	68.7	46.8	21.5	44.2	40.5

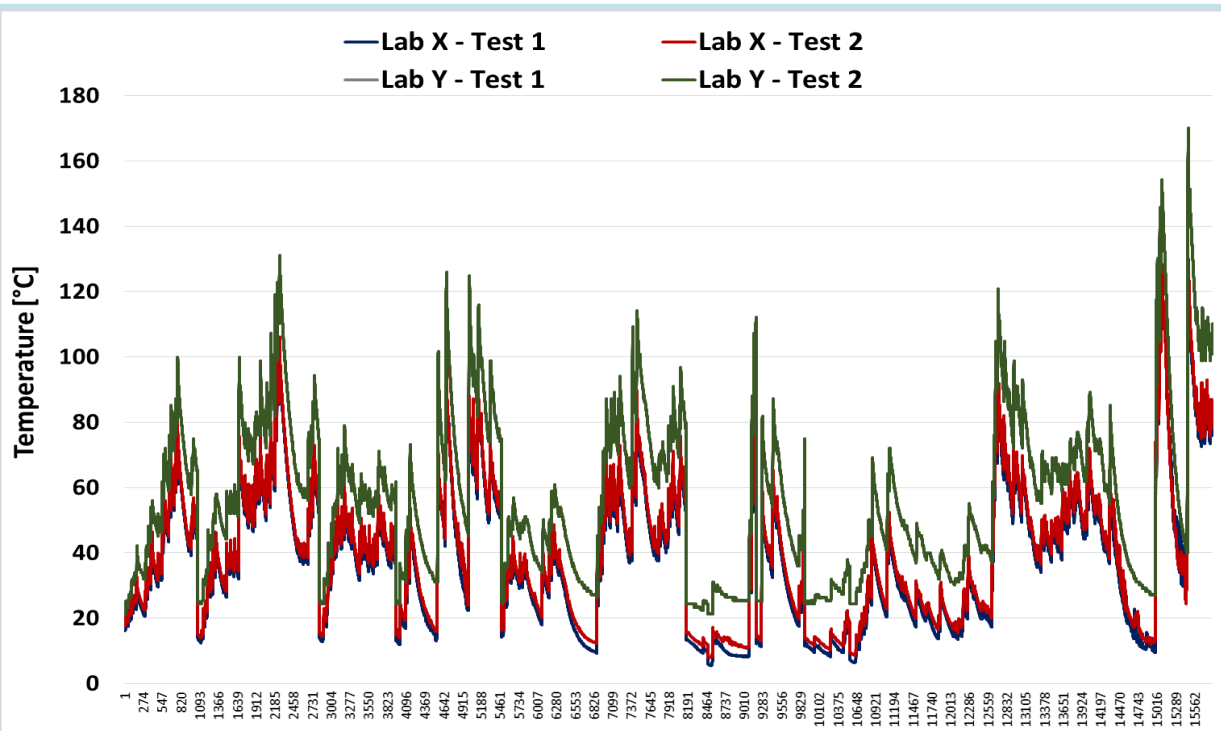
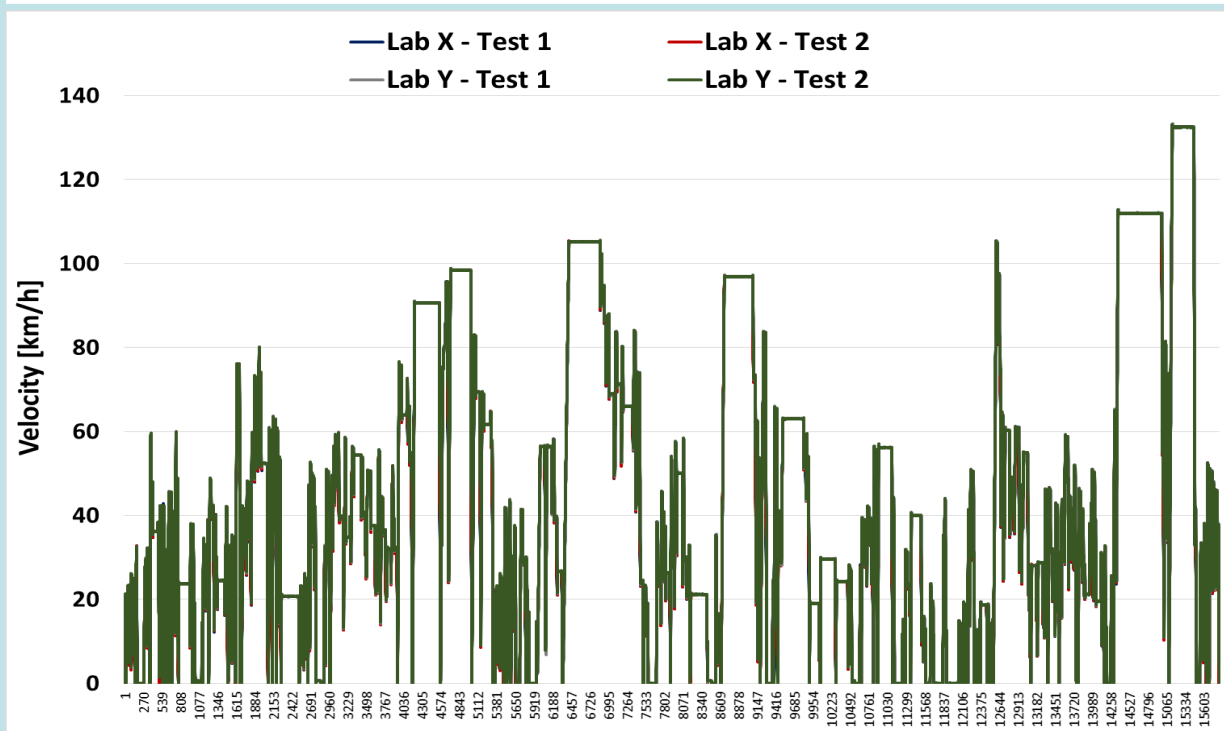
VALIDATION OF THE NOVEL BRAKING CYCLE RR EXERCISE - OBJECTIVES

Primary Objective: Reproduce the novel cycle at brake dyno level and compare the temperature levels of the brake system to those recorded at the vehicle level



VALIDATION OF THE NOVEL BRAKING CYCLE RR EXERCISE - OBJECTIVES

Primary Objective: Repeat the novel cycle successfully at brake dyno level within the same laboratory and between different laboratories



VALIDATION OF THE NOVEL BRAKING CYCLE RR EXERCISE - OBJECTIVES

Ultimate Objective: Provide TF2 and the PMP IWG with recommendations on the application of the protocol to avoid incomparable measurements

- Recommendations regarding the adjustment of the cooling air flowrate
 - a) Application of a fixed air speed (i.e. 45 kph), b) Adjustment based on vehicle's trip 10 cooling curve, c) Adjustment based on vehicle's two different cooling curves
- Recommendations regarding the measurement of the brake temperature
 - a) Application of sliding or/and embedded TCs, b) Correct positioning of TCs
- Recommendations regarding the application of soak times
 - a) Wait until 20°C brake temperature, b) Wait until a higher brake temperature (i.e. 40°C), c) Apply soak times of fixed duration (i.e. 5 min)

VALIDATION OF THE NOVEL BRAKING CYCLE WRAP-UP

	Laboratory	Representative(s) in TF1
1	AUDI	Sebastian Gramstat
2	BREMBO	Francesco Riccobono
3	FORD (Reference Lab)	Jarek Grochowicz & Marcel Mathissen
4	GM	Matt Robere
5	ITT Motion	Agusti Sin & Simone Ansaloni
6	LINK/Europe	Marco Zessinger
7	LINK/US	Carlos Agudelo & Alejo Hortet
8	TMD FRICTION	Andreas Paulus & Ilja Plenne
9	TU Ilmenau/BMW (Validation Lab)	David Hesse/Rasmus Leicht

- **25 full group meetings plus several preparation bilateral meetings**
- **A full experimental campaign (RR) with 2 sets of 6 repetitions of the novel cycle plus several adjustment tests with dummy parts**
- A detailed report of the main results and statistics of the RR along with recommendations on the correct application of the cycle
- Proposal on how to treat other vehicle classes and how to apply the novel cycle to other vehicle classes



Any questions?

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