Euro 5 Effect Study Update

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Introduction

Euro 5 Effect Study

The Effect Study

should confirm the measures in the Euro 5 (2020) package:

Requirements in:
Regulation EU No. 168/2013

Supplemented by:
Regulation EU No. 134/2014

Article 23 (4): *The Effect Study shall evaluate the* ***air quality and the share of pollutants contributed by L-category (Test types I to VIII)***

and should also assess:

Feasibility of further elements (post-Euro 5):
off-cycle emission testing, in-service verification, particle number

Euro 5 Effect Study

Pre-Study (JRC)

Phase 0: Experimental Test Programme

Effect Study (JRC)

Phase 1: Stocktaking, Public Survey, Literature survey

Effect Study (Contractor + JRC supervision)

Phase 2: Experimental Test Programme, Cost/benefit

Phase 3: Validation Programme, Report

Euro 5 Effect Study - Deadlines

- **Report on Pre-study: 16-Feb-2016**

(Public Survey out now)

- **Completion of Euro 5 Effect Study Final Report, *September 2016***

- **Commission to report to Parliament, *in due course***

Euro 5 Effect Study

European Commission

Background

i) Asymmetric pollution by L-cat vehicles: small fleet, large contribution (urban THC, CO, PM).
ii) In off-cycle mode (hence in real-driving), tailpipe emissions and/or fuel consumption may significantly differ from type-approval.
iii) Vehicle speed profile poorly correlates with engine load.

Scope

The vehicle should be clean and energy efficient at each feasible operation point under the max torque curve.

Emission abatement technology which is neutral wrt to vehicles and test types (ratio part-load area vs feasible operation range).

Method

Engine load variable (e.g., engine torque, CO_2 mass emissions, etc.)

→ **quality, quantity and dynamics** of emission sampling used to compare part-load sampling conditions among various test types and vehicle types.

Euro 5 Effect Study

European Commission

Sufficient and comprehensive assessment of tailpipe emissions in the part-load area

Quality

Distribution of emission sampling within the specified part-load area of testing (engine load Vs engine speed). Indicators:

- Covered part-load area: scatter area defined by engine speed and engine load compared to maximum torque area.
- Drive-ability: driver violations in the emission laboratory test cycle (actual vs desired vehicle speed).

Quantity

Intensity of part-load area sampling.

Dynamics

Statistics on the slope of "jumps" between the various engine speed and engine load matrix points.

Euro 5 Effect Study - Timeline

Item	Sep 2014	Mar 2015	Apr-May 2015	Jul 2015	Dec-Jan 2015-2016
Phase 0 Pre-study	Start	Testing	Testing	Analysis	Working doc
Phase 1 Statistics	Analysis	Analysis	End	--	Final doc
Phase 1 Public Survey	--	Launch	Open	End	Printed
Phase 2 Call for Tender	--	Tech Spec	Tech Spec	Open: JRC tests	Contractor Appointed

Update

Pre-Study (JRC)

Pre-Study - Experimental

Tested Vehicles: ≈ 200 roller bench tests

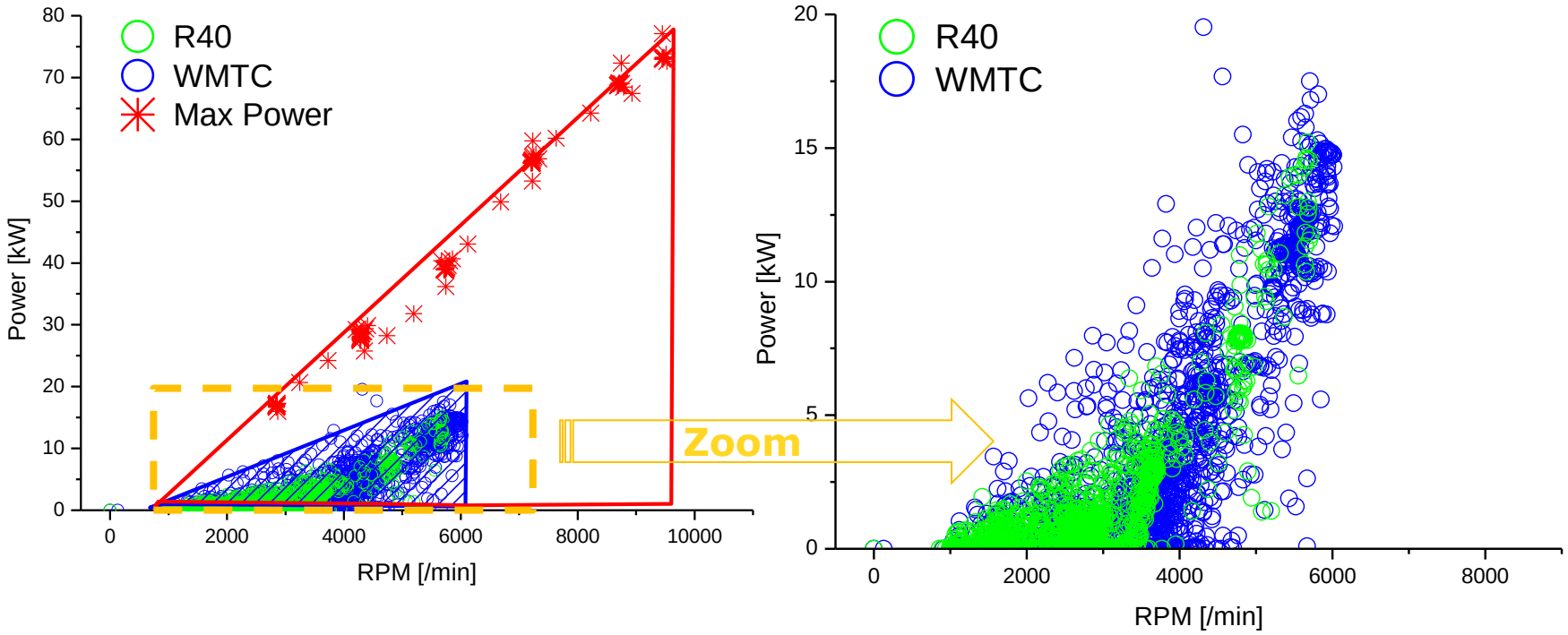
Vehicle	Cat	Stroke	Displacement [cm³]	Technology	Power [kW]	Mileage [km]	Year	Euro
1	L1e-B	4	50	Carburetor 2-way-cat	≈3	2500	2010	2
2	L1e-B 25 km/h	4	50	Carburetor 2-way-cat	≈3	2000	2012	2
3	L1e-B	2	50	Carburetor 2-way-cat	≈2	2500	2010	2
4	L1e-B	2	50	Carburetor 2-way-cat Manual trans.	≈3	5000	2008	2
5	L1e-B 25 km/h	4	50	Carburetor 2-way-cat	≈3	3000	2012	2
6	L3e-A1	4	125	E.I. 2-way-cat	8	>2000	2010	3

Pre-Study - Experimental

Vehicle	Cat	Stroke	Displacement [cm³]	Technology	Power [kW]	Mileage [km]	Year	Euro
7	L3e-A2	4	300	E.I. 2-way-cat	16	3000	2012	3
8	L3e-A2	4	400	I.E. 2-way-cat	24	27000	2013	3
9	L3e-A3	4	900	I.E. 2-way-cat	100	15000	2006	2
10	L3e-A3	4	700	Manual trans.	50	26000	2008	3
11	L5e-B	4	400	Manual trans.	12	5000	2010	2
12	L7e-A1	4	500	I.E. 2-way-cat	14	500	2014	2

Pre-Study - Experimental

High Performance Motorcycle (L3e-A3) with manual transmission



Larger area covered by WMTC → maximized sampling in the part-load area

Considerable empty, unsampled area between WOT Test and WMTC/R40

Pre-Study - Experimental

WMTC vs R47/R40 cycles: QUALITY

Parameter	WMTC / old cycle
Quality (area covered)	10/2

The WMTC generally covers larger areas

Exceptions: Vehicles at the edge of the L3-A1-A2 class (R40 speed profile has larger speed than WMTC)

- **Veh6, L3e-A1: same area covered**
- **Veh7, L3e-A2: 30% (WMTC) vs 50% (R40) 100% WOT test**

→ There are vehicles with WMTC less severe than R40.

Pre-Study - Experimental

WMTC vs old cycles: QUANTITY

Parameter	WMTC / R47-R40
Torque = 0	5/7
Max torque	11/1

Zero-torque (Time-Normalized):
WMTC is slightly less severe for L1 (up to 7%)
WMTC is more severe for the other sub-categories

Max Torque:
The WMTC is more severe.
(Larger engine loads –Torque- than the older cycles)

Pre-Study - Experimental

Engine load variables (green = investigated)

	Torque	CO_2 mass	Fuel consumption	Handle position	Exhaust Flow	MAP	Throttle position
Veh1							
Veh2							
Veh3							
Veh4							
Veh5							
Veh6							
Veh7							
Veh8							
Veh9							
Veh10							
Veh11							
Veh12							

Pre-Study - Experimental

Engine load variables

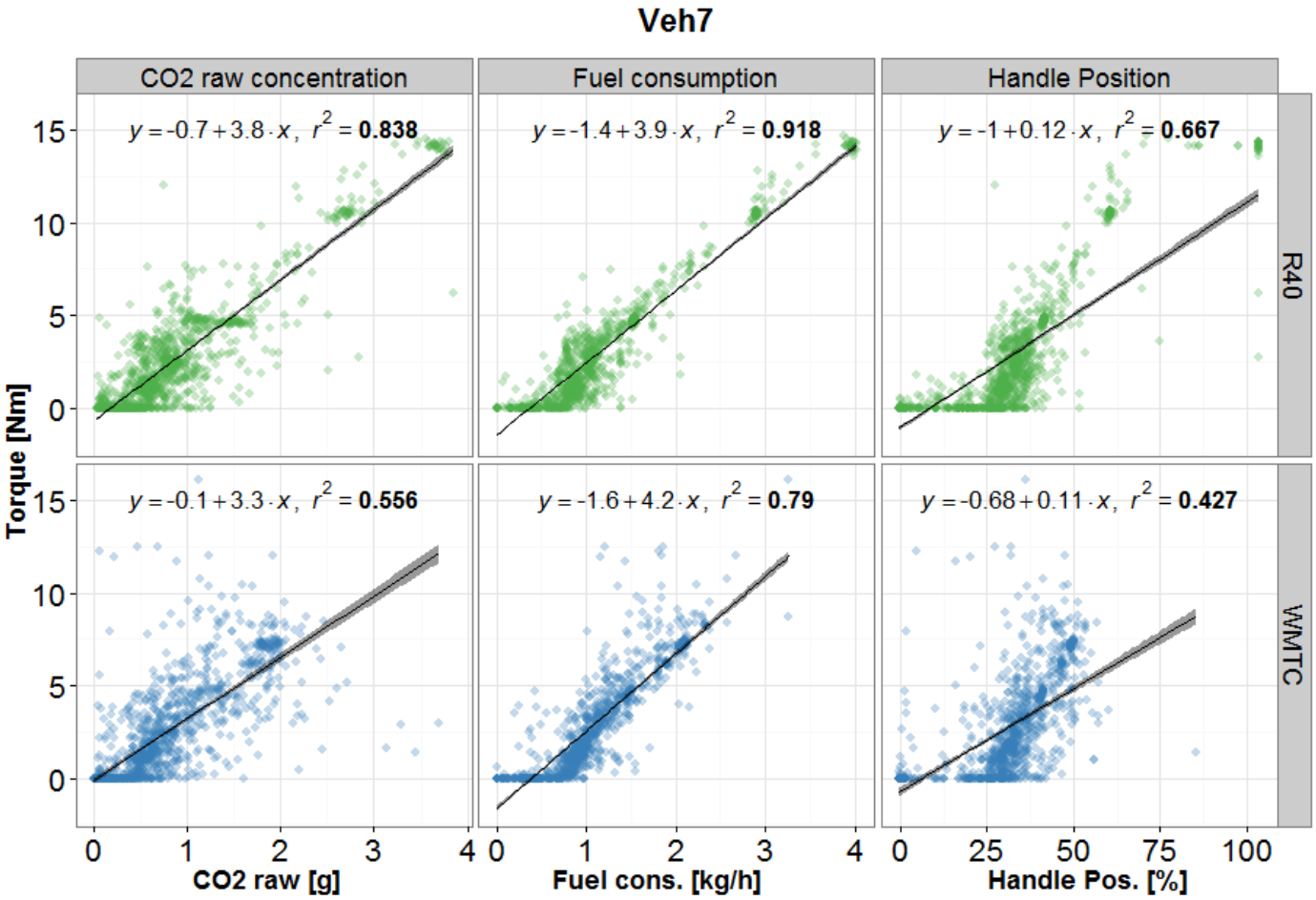
Correlation between the Torque variable and the investigated load variables over the WMTC.

	Sub-categories	CO_2	Fuel Cons.	Handle position	Exhaust flow	Vehicle speed	MAP	Throttle position
Veh1	L1e-B	0.16	0.15	0.57	0.50	0.17		
Veh2		0.15	0.15	0.36	0.57	0.18		
Veh3		0.67	0.27	0.56	0.62	0.24		
Veh4		0.15	0.01	0.19		0.01		
Veh5		0.47	0.36		0.47	0.21		
Veh6	L3e-A1	0.56	0.27	0.55	0.56	0.36	0.62	
Veh7	L3e-A2	0.56	0.79	0.43	0.54	0.33		
Veh8	L3e-A2	0.83	0.82	0.84	0.77	0.61		0.87
Veh9	L3e-A3	0.41			0.45	0.56		0.76
Veh10	L3e-A3	0.09		0.85	0.07	0.63		
Veh11	L5e-B	0.45			0.10	0.10		
Veh12	L7e-A1	0.47	0.74		0.13	0.35		0.86

- **Engine load variables are vehicle specific → first a roller bench test is needed**
- **For mopeds and 1 tricycles indications are less clear**

Pre-Study - Experimental

Example of correlation plots



Update

Phase 1 (JRC)

Effect Study - Phase 1

Public Survey

Open May-July 2015

Scope

Gather opinions across the **EU and internationally** on the **EURO 5 ENVIRONMENTAL STEP FOR L-CATEGORY VEHICLES**

Results shown in EPPR12

Report now available at JRC Repository Service:

http://publications.jrc.ec.europa.eu/repository/handle/JRC98900

Update

Phase 2
(Contractor + JRC supervision)

Effect Study - Phase 2

Task 1.1.1.: Assessment Type I - **Tailpipe emissions test after cold start**
Sub-task 2.1.1.1: Assessment of the **applicability of the WMTC** (Worldwide harmonized Motorcycle Testing Cycle) to all the L-category vehicle types.
Sub-task 1.1.1.2: Assessment of the appropriateness of the **Euro 5 tailpipe emission limits** (Annex VI(A) of Reg. 168/2013)
Sub-task 1.1.1.3: Assessment of the separate **NMHC limit**
Sub-task 1.1.1.4: Assessment of **the impact of ethanol** in the reference fuel on the test type I results
Task 1.1.2: Assessment Type II – Tailpipe emissions at (increased) idle and free acceleration
Task 1.1.3: Assessment Type III – Emissions of **crankcase gases**
Task 1.1.4: Assessment Type IV – **Evaporative emissions test**
Sub-task 1.1.4.1: Assessment of evaporative emission test procedures set out in Annex V to Regulation (EU) No 134/2014, in particular the permeation and SHED test procedures
Sub-task 1.1.4.2: Investigation of the cost effectiveness of a 25% lower Euro 5 evaporative emission limit compared to the Euro 4 limit for vehicles subject to the SHED test
Sub-task 1.1.4.3: Investigation of the impact of fuel quality on the evolution of fuel permeation rate over time as well as the ageing effects of the carbon canister
Sub-task 1.1.5.1: Validation of **distance accumulation cycle (SRC-LeCV)**
Sub-task 1.1.5.2: Validation of assigned Deterioration Factors and useful life values
Task 1.1.6: Assessment Type VII – Energy efficiency tests (CO2 emissions, fuel/energy consumption and electric range measurements)
Task 1.1.7: Assessment functional on-board diagnostics requirements and Type VIII – OBD environmental tests + background information
Sub-task 1.1.7.1 - On-board diagnostic requirements – expansion functionality **OBD stage I to OBD stage II** – relevance for effective and efficient vehicle repair
Sub-task 1.1.7.2: Type VIII test - assessment of the OBD emission thresholds (OTLs) set out in the table laid down in Annex VI(B2) to Regulation (EU) No 168/2013
Sub-task 1.1.7.3 - On-board diagnostic requirements – assessment of the cumulative cost effectiveness of sub-tasks 1.7.1. and 1.7.2. and technical feasibility of supplemental OBD stage II

Task 2: Research and assessment of further elements listed in recital 12 of Regulation (EU) No 168/2013 **(beyond the Euro 5 step**)
Task 2.2.1: Off-cycle emissions testing
Sub-task 2.2.1.1. Experimental test programme on technical feasibility **off-cycle emission requirements**
Sub-task 2.2.2.2.Benefit / cost ratio range and cost effectiveness analysis off-cycle emission requirements
Task 2.2.2: In-service conformity verification testing
Task 2.2.3: Assessment of the need to expand the **PM limit** scope to other vehicle categories than those already subject in the Euro 5 step and introduction of a **PN limit**

Effect Study - Phase 2

European Commission

Test vehicles at JRC

Vehicle	Category	Stroke	Displace-ment [cm³]	Technology	Power [kW]	Mileage [km]	Year	Euro
1	L1e-B (HS moped)	2	50	Gasoline 1 cyl., Manual trans., Carburetor, 2-way-cat	≈4	500	2015	2
2	L6e (minicar)	4	500	Diesel 2 cyl. Common-rail EI Diesel oxicat	≈2	500	2015	2
3	L1e-B (HS moped)	4	50	Gasoline 1 cyl., CVT, Carburetor, 2-way-cat	≈2	500/ 1000	2015	2
4	L1e-B (HS moped)	2	50	Gasoline 1 cyl., CVT, Carburetor, 2-way-cat	≈2	500/ 1000	2015	2
5	L1e-A (powered cycle)	2	30	Gasoline 1 cyl., CVT, Carburetor, 2-way-cat	1	>1000	2009	2

Effect Study - Phase 2

European Commission

Awaiting at JRC

Vehicle	Category	Stroke	Displacement [cm³]	Technology	Power [kW]	Mileage [km]	Year	Euro
6	L7e-B1 (all terrain quad)	4	500	Gasoline 1 cyl., Manual trans., EFI, 2-way-cat	≈10	500	2015	2
7	L3e-A1	4	150	Coming soon…				
8	L3e-A2	4	300					
9	L1e-B	2	50					

Update

Particle Number

(post Euro 5)

Phase 2 – Particle Number

European Commission

Particle number (PN) method

Solid particles that do not evaporate at 350°C with diameters above 23 nm.

Rationale

There is no significant sub-23 nm fraction for these technologies

Chronology

2009 PN for European diesel passenger cars

2013 PN for heavy duty engines

2014 PN for gasoline direct injection passenger cars

L-category (beyond Euro 5)

- The portion of solid particles not counted with the current PN method
- Artefacts below 23 nm due to the large amount of semi-volatile material

Phase 2 – Particle Number

2015-24-2512
Published 09/06/2015

doi:10.4271/2015-24-2512
saeeng.saejournals.org

Particle Emission Measurements from L-Category Vehicles

Barouch Giechaskiel, Alessandro Zardini, and Giorgio Martini
Joint Research Centre, EC

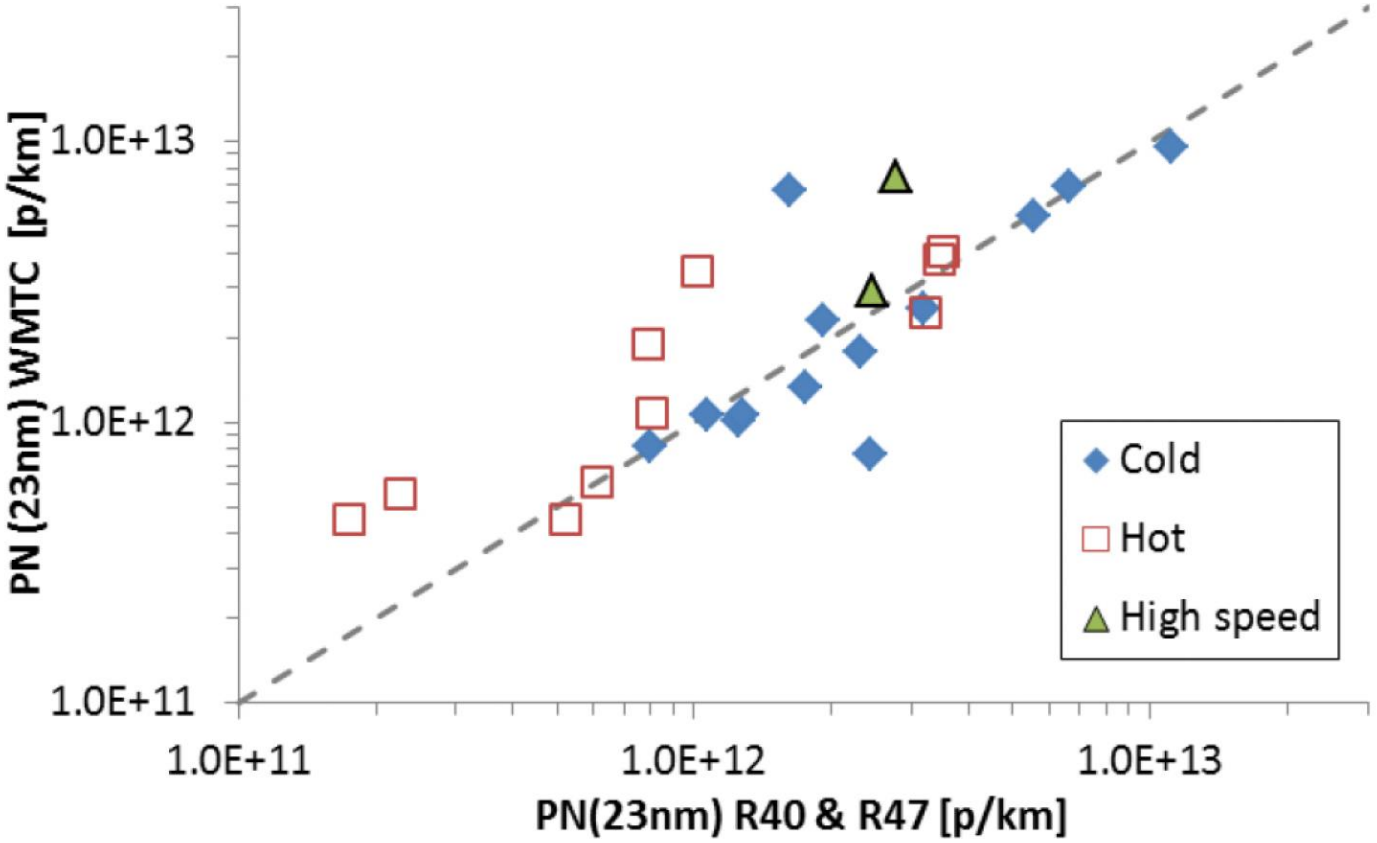
Fleet
5 mopeds, 9 motorcycles, 2 tricycles (one diesel) and 1 quad

Method
PN legislation compliant systems with counters >23nm and >10nm

Additional
Catalytic strippers, counters >3nm, particle sizers

Phase 2 – Particle Number

WMTC vs older cycles



Ensemble graph with all available data and vehicles for particles size >23nm (*Giechaskiel et al. 2015, SAE*)

Phase 2 – Particle Number

Artifacts Particles formation <23nm and <10nm at high load

Tailpipe vs Dilution Tunnel: >23nm 10-20%, <23nm up to 50%

PN levels

Vehicle	PN Level / $6x10^{11}$ p/km (limit for cars)
Mopeds	3-20
Motorcycles	2-4
Quad	12
Tricycle	3

WMTC vs older cycles: good correlation (same order of magnitude)

PMP: up to 70% non-counted particles (up to 40% for cars)

Compromise: PMP with 10nm cutoff

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