Euro 5 Effect Study Update

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Introduction
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*

Environmental and Propulsion unit Performance Requirements for type approval of Euro 5 vehicles

and should also assess:

Feasibility of further elements (post-Euro 5):

*off-cycle emission testing, in-service verification, particle number*
Article 23 (4)
By 1 January 2016, the Commission shall carry out a *comprehensive environmental effects study*. The study shall evaluate the air quality and the share of pollutants contributed by L-category vehicles and shall cover the requirements of test types I, III, IV, V, VII and VIII.

Article 23 (5)
Based on the findings referred to paragraph 4, the Commission shall by 31 December 2016 present to the European Parliament and the Council a report.
Experimental Test Programme (Sep14-Jun15)

Phase 1: Stocktaking and data mining, stakeholder consultation, literature survey, planning for phases 2 and 3 (Call for Tender).

Phase 2: Experimental test programme, Cost/benefit analysis, Impact assessment

Phase 3: Validation programme, Report
Validation Programme and Final Report

• Completion of Final Report  
  *September 2016*

• Commission to report to Parliament  
  *December 2016*
**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.
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.
Update

Pre-Study (JRC)
## Pre-Study & Phase 1 (JRC)

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<td>Results</td>
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<td>End (Tech Spec)</td>
<td>Open</td>
<td>Target to appoint Contractor</td>
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Pre-Study - Experimental

Tested Vehicles: > 170 roller bench tests

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## Pre-Study - Experimental

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High Speed Moped (45 km/h) with CVT - R47 and WMTC cycles

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

Relatively little empty area between WOT Test and WMTC/R47 cycles
High Speed Moped (45 km/h) with manual transmission

Larger area covered by WMTC $\Rightarrow$ maximized sampling in the part-load area

Considerable empty, unsampled area between WOT Test and WMTC/R47
L3e-A3

High Performance Motorcycle with manual transmission

Larger area covered by WMTC $\Rightarrow$ maximized sampling in the part-load area

Considerable empty, unsampled area between WOT Test and WMTC/R47
Example of correlation plots
Update

Phase 1 (JRC)
**Survey:** public, open May-July 2015

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

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<td>Responded</td>
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Market increase L-cat (5 years), not homogeneously for sub-cat: L1, L3 ↑
L5, L6, L7 ↔
L4 ↔ ↓

**Pros** Euro 5 will Reduce pollutant (96%), Protect public health (63%), Increase energy efficiency (50%).

**Cons** 87.5% increased production costs, 48% technical challenges, and 44% vehicle prices increase
Type I – tailpipe emission tests after cold start

**WMTC** is moderately representative of L-cat driving, the lack of knowledge dominates.

Technically feasible to comply with **Euro 5 limits** for THC, NOx, CO using existing technologies.

Respondents have a lack of knowledge on whether the **PM (and PN)** limit can be met. They think **DPF and GPF** will be involved, and that this is a potential problem for the L-cat.

**Estimated Cost increase (by respondents)**

- min €101-200 for L1e and L2e
- med
- max €201-300 for L7e B and L7e-C

**Ethanol** in fuel is expected to affect Test IV - evaporative emission test - and leading to canister deterioration.
Type III – Emissions of Crankcase Gases
Unburnt crankcase gas emissions are considered a threat to human health and environment, but there is uncertainty whether crankcase emissions are higher than tailpipe emissions.

In addition, there is a general lack of knowledge on whether inefficient operating crankcase systems have a damaging effect on engine life and whether the verification method for the crankcase ventilation system is appropriate and beneficial. Slightly preferred the vacuum than the overpressure method.

Type IV Evaporative Emissions
There is a general lack of knowledge on whether the fuel permeation test and lower SHED test limit are appropriate for L-category vehicles or whether Euro 5 SHED test complaint vehicles need and additional/modified hardware.
Type V - Durability of Pollution Control Devices
There is a general lack of knowledge on the most appropriate type-approval durability test, whether AMA cycle should be phased-out and whether an increase in distance accumulation for L3e –A motorcycle is justified.

Type VII Energy Efficiency Test
A range of technologies have the potential to improve fuel efficiency of L-category vehicles (e.g. alternative fuels, battery technology, gas recirculation, intelligent transmission).
Functional on-board diagnostics and Type VIII environmental
On-Board Diagnostic test

OBD is seen as providing better diagnostic quality information to the repair, enhance functional safety requirements and reduce repair costs to users.

However, there may be increased vehicle costs for consumers, longer vehicle development and production and increased research and development efforts.
Off-Cycle Emissions

It is generally considered that future off-cycle emission requirements should prevent the optimisation of the environmental performance of the vehicle to pass only the test type approval.

Chassis dynamometer tests might be also used to obtain off-cycle information.

OCE not needed for limited speed/power vehicles (those for which the WOT curve is close to the WMTC).
The Environmental Effect study should provide further analysis and clarifications on the following questions:

Does the WTMC represent real-world conditions for L-category vehicles? (The question does not resemble the Effect Study approach: quantity and quality of sampling in the load-speed area w.r.t. an assumed part-load area)

Can L-category vehicles adapted for technical progress meet the PM and PN limits?

How significant are crankcase emissions?

What is the most appropriate durability test and is the mathematical method using assumed deterioration factors an appropriate approach to assess durability of pollutant control devices at type-approval?

What is the impact of alternative fuels, OBD stage II, standard battery package and an HC limit on off-cycle emissions on L-category vehicles?
Source of the data

Motorcycles and Mopeds placed on EU market: Circulating park and New Registration

- **ACEM website**
  "Powered two wheeler registrations in EU and EFTA countries 2014 statistical release" (Feb. 2015)
  "European powered two wheeler market statistics" (Mar. 2014)

- **DIONE fleet impact model**
  consistent with TRACCS project output based on PRIMES baseline projection

- **EUROSTAT databases**
  updated on the 02/03/2015
  accessed on the 06/05/2015

Type Approval figures:

- **KBA databases**
  Kraftfahrt-Bundesamt - Federal Motor Transport Authority
  2009 and 2014 databases
Circulating park
of Mopeds and Motorcycles in EU28

- EUROSTAT data displays lower values than ACEM and DIONE data
- Up to 2012, ACEM and DIONE Motorcycle data match, however Moped data diverge $\implies \neq 4$ M vehicles in 2012
New registration of Mopeds and Motorcycles in EU28

- Up to 2012, **ACEM** and **EUROSTAT Bicycle** data match
- [2004-2011], **DIONE Motorcycle** data is greater (max. ≠ 0.3 M vehicles in 2008)
- Last year trend: **ACEM** data reduce by 10% while **DIONE Moped** data stabilise
2014 Circulating park in EU28
Mopeds and Motorcycles in millions (source DIONE)
In 2014, Italy, Spain, Germany and France account for 2/3 of circulating park and 3/5 of new registration in EU28.
## Literature study

Number of references collected = 101

### Keywords

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### Points

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> Importance of **Pre-Study** and **Effect Study**

> **Particle Emission Measurements from L-Category Vehicles** Giechaskiel et al. 2015, SAE Journal, 2015-24-2512
Update

Phase 2
(Contractor + JRC supervision)
Call for Tender is closed and offers under evaluation

- **Task 1**
  Experimental assessment and verification programme of measures within the Euro 5 Environmental Step as for Art.23 (4) and (5), Reg.168/2013
  (different Test types + cost/benefit)

- **Task 2**
  Research and assessment of further elements as for Recital 12 of Reg.168/2013
  (e.g., off-cycle emission testing, in-service verification, expand PN limits)
## Study - Phase 2 (Contractor)

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This is beyond euro 5
Study - Phase 2 (Contractor)

Task 1.1.1.: Assessment Type I - Tailpipe emissions test after cold start
Sub-task 1.1.1.1: 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
Update

Phase 2, Additional features
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

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%

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**PN levels**

**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
Many thanks to:

A. Bonamin, G. Lanappe, B. Giechaskiel, M. Clairotte, G. Haq, G. Martini

THANKS FOR YOUR ATTENTION!