Post Euro 6/VI Norms: How well are we prepared for the next emission level towards Near Zero Impact

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FEV Diesel Powertrain 3.0 conference • 8-9 July 2020
Exhaust emissions control technologies for original equipment, retrofit and aftermarket for all new cars, commercial vehicles, motorcycles, and non-road mobile machinery

AECC is # 78711786419-61 in EU Transparency Register and has consultative status with the UN Economic and Social Council (ECOSOC)
Content

- **Introduction**
  - Euro 7 process
  - Technologies available to handle real-world operation emissions

- Light-duty Diesel - Ultra-low emissions diesel demonstrator

- Heavy-duty Diesel - Real-world operation data of Euro VI vehicles

- Summary and outlook
Euro 7 confirmed in EU Green Deal communication

For cars, vans, buses and trucks

- European Commission working group: Advisory Group on Vehicle Emission Standards (AGVES)
- Studies by CLOVE consortium until Mid of 2021
- European Commission proposal expected in 2021 followed by ordinary legislative procedure with European Parliament and Council

Schedule

CLOVE

[Timeline]

EC/AGVES

[Timeline]
Technologies available to handle real-world operation emissions

For light- and heavy-duty applications

- Emissions control technologies significantly reduce pollutant emissions as part of an integrated approach
- Euro 7/VII will drive further innovation in
  - Catalyst and filter technology design
  - Emissions control system layout
  - System control
Technologies available to handle real-world operation emissions

For light- and heavy-duty applications

- Common system layout characteristics to handle real-world operation emissions
  - Close-coupled catalysts for cold-start and low speed/load driving in the city
  - Underfloor catalysts for high speed/load area on the motorway
  - Total catalyst and filter volume to cope with peak engine pollutant flow

- Examples of available systems for light-duty diesel

Source: Daimler

Source: VW
Technologies available to handle real-world operation emissions
For light- and heavy-duty applications

Examples of available systems for heavy-duty diesel

Example of announced system with close-coupled components for heavy-duty diesel
Significant reduction of diesel NOx emissions to Euro 6d

Source: ACEA/JAMA PEMS data consulted 19 November 2019
Ultra-low emissions diesel demonstrator

- C-segment Vehicle
  - 1700 kg
- Drivetrain
  - Manual gearbox, 6-speed
  - 48 Volt mild-hybrid (belt-driven, P0)
- Engine
  - 1.5l, 4-cylinder, 2-valve
  - EGR: uncooled HP and cooled LP
- Euro 6b type-approval (LNT + DPF)
- Reference paper
Emissions controls to cover wide range of driving conditions

- LNT + dual-SCR system
- Supported by 48V mild-hybrid

EGR: Exhaust Gas Recirculation
HP/LP: High/Low pressure
cc: close-coupled
LNT: Lean NOx trap
SCR: Selective Catalytic Reduction
DPF: Diesel Particulate Filter
SDPF: SCR on DPF
uf: underfloor
ASC: Ammonia Slip Catalyst
Robust NOx control over wide range of driving conditions

- Euro 6d Not-to-Exceed Limit
- NOx in mg/km
- EAT deNOx in %
- Average vehicle speed in km/h
- Diesel fuel
- HVO fuel

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Other approaches exist to achieve low NOx

- **Bosch [1]:** DOC + dual-SCR
- **FEV [2]:** DOC + dual-SCR
- **Continental [3]:** eDOC + dual-SCR

NOx in mg/km

3. G. Avolio, et al.; “Super Clean Electrified Diesel: Towards Real NOx Emissions below 35 mg/km”, 27th Aachen Colloquium, 2018
Objective & scope of Heavy-duty test programmes

- Identify real-world emissions of Euro VI vehicles for broad range of applications
- Investigate
  - Impact of Euro VI-D/E
  - Actual real-world operation vs. Euro VI In-Service Conformity
  - Actual real-world value (=raw data integrated over test) vs. ISC data evaluation
- Available data for the study
  - Existing real-world operation database of 23 vehicles (Euro VI-A to VI-C)
  - Real-world operation data measured on 3 vehicles (Euro VI-D)
  - Detailed testing on 1 vehicle (N3 Euro VI-C distribution truck)
    - Euro VI ISC route
    - Actual real-world operation
Data confirms low emissions of Euro VI vehicles on average

Most vehicles in database have low emissions in real-world operation according to

- Average of all data
- ISC data post-processing
Data confirms low emissions of Euro VI vehicles on average

- Several vehicles stay below Euro VI NTE limit during most of real-world operation
  - Euro VI-A regional bus
  - Euro VI-C national distribution truck
ISC post-processing has significant impact

- Most vehicles in database have low emissions in real-world operation according to:
  - Average of all data
  - ISC data post-processing
- Highest Moving Average Window in real-world operation can be factor of 5-10 higher
- Investigated next:
  - Effect of data exclusions
  - Frequency of high emissions
Data exclusions affect urban report value for Euro VI-A to VI-C

Euro VI-A N3 vocational truck

- Urban operation: 75% or the total trip, maximum averaged emissions 11 times the current NOx limit

91% of MAW above Euro VI NTE limit

Data excluded: cold start, 20%PT, 90th cumulative percentile.
Data exclusions affect urban report value for Euro VI-A to VI-C

- Euro VI-C N3 long-haul truck
  - Urban operation: 37% or the total trip, maximum averaged emissions 6 times the current NOx limit

- 32% of MAW above Euro VI NTE limit

Data excluded: cold start, 20%PT, 90th cumulative percentile.
Data exclusions affect urban report value for Euro VI-A to VI-C

Example of Euro VI-C distribution truck

ISC route
- Stringency increases from Euro VI-D to VI-E
- Truck would comply up to Euro VI-D

Actual real-world operation
- 100% of time below 10% power threshold
  - Not covered by ISC up to Euro VI-E
- Raw data integrated over test is factor 4-5 higher
Data exclusions affect urban report value for Euro VI-A to VI-C

Example of Euro VI-C distribution truck

Urban part of the ISC route reflects actual real-world emissions

![Graph showing NOx emissions for different load conditions and Euro VI limits.](image)
Improvements for Euro VI-D, but high emission events still occur

- Euro VI-D N2 rigid truck
  - Urban operation: 46% or the total trip, maximum averaged emissions 3 times the current NOx limit

Data excluded: cold start, 10%PT, 90th cumulative percentile.

- 21% of MAW above Euro VI NTE limit
Improvements for Euro VI-D, but high emission events still occur

- Euro VI-D N3 tractor tanker semi-trailer
  - Urban operation: 31% or the total trip, maximum averaged emissions 5 times the current NOx limit

- 19% of MAW above Euro VI NTE limit

Data excluded: cold start, 10%PT, 90th cumulative percentile.
Summary and outlook

- AECC test programme data presented
  - Low NOx emissions from a diesel passenger car over a wide range of driving conditions
  - Heavy-duty ISC post-processing has significant impact on report value for urban operation

- AECC welcomes the EU Commission’s legislative initiative to prepare Euro 7/VII
  - A new era for vehicle emissions control started under Euro 6/VI with the introduction of RDE (Euro 6d-TEMP) and PEMS testing (Euro VI-A) within the legislation
  - All predictions show the ICE will be included in the majority of the (electrified) powertrain mix in the medium term
  - There remain areas where improvements to the emission standards are required
    - Real-world emissions measurement framework
    - Setting emissions limits to ensure the health and well-being of everyone

- AECC will continue to demonstrate that technologies are available today to effectively control emissions from ICE under real-world operation towards near zero-impact on air quality
THANK YOU!

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