Diesel is future proof
Association for Emissions Control by Catalyst (AECC AISBL)

AECC members: European Emissions Control companies

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)
Real-world NOx emissions gap is issue of pre-RDE diesels

Source: TRUE initiative

Source: the ICCT
Content

- EU Real-driving Emissions legislation
- Low NOx emission diesel cars: a reality
- AECC ultra-low emissions diesel demonstrator
- Gasoline PN emissions
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
  - CF in final step accounts for PEMS error margin (Portable Emissions Measurement Systems)
- Two stages added to Euro 6 legislation: Euro 6d-TEMP and Euro 6d

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NOx CF2 = 1.0 + 0.43 error margin
PN CF = 1.0 + 0.5 error margin

Today

NT: New Types
All: All Types

UBIA – 28 November 2019
PEMS equipment used to measure emissions on the road
In-Service Conformity and Market Surveillance are key
Defined in 4th legislative EU-RDE package - Regulation (EU) 2018/1832

- Applies to New Types as of 1 January 2019 and All New Vehicles as of 1 September 2019
- Mandatory tests
  - Type 1: RDE
  - Type 1: WLTP
- Optional tests
  - Type 4: evaporative emissions
  - Type 6: low ambient temperature
- Some examples of process flow in next 2 slides
In-Service Conformity and Market Surveillance are key
Defined in 4th legislative EU-RDE package

Example of the new system for In-service conformity
Evidence through remote sensing, PEMS, SEMS, etc..
Actors: Anybody

Validation of collected data
(scope: remove wrong data, biased testing, etc.)

1. Yearly Publication of validated surveillance data

Tampering investigations
Info for ISC
Defeat Device investigations

Source: Z. Kregar, “Update on EU Air Quality and vehicle emissions policies”, EIONET meeting on environment and transport, 2018, Copenhagen
In-Service Conformity and Market Surveillance are key
Defined in 4th legislative EU-RDE package

Source: Z. Kregar, “Update on EU Air Quality and vehicle emissions policies”, EIONET meeting on environment and transport, 2018, Copenhagen
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- EU Real-driving Emissions legislation
- Low NOx emission diesel cars: a reality
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- Gasoline PN emissions
RDE has significantly improved diesel NOx emissions

On-road emissions of Euro 6d(-TEMP) cars are well within standards

Source: ACEA/JAMA PEMS data consulted 19 November 2019

Source: Handbook of Emissions Factors 4.1, UBA press release 11 September 2019
RDE has significantly improved diesel NOx emissions

Trend is confirmed by 3rd party testing
Light-duty diesel emissions control technology evolution

Introduction of individual deNOx technologies for Euro 6a/b

Combination of deNOx technologies for Euro 6d-TEMP

Further integration for Euro 6d

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Source: BMW

Source: VW

Source: Hyundai

Source: Daimler

Source: VW

UBIA – 28 November 2019
Content

- EU Real-driving Emissions legislation
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AECC ultra-low NOx emissions diesel demonstrator

- Robust NOx control over wide range of driving conditions
  - Low speed/load e.g. city driving
  - High speed/load e.g. motorway driving
  - Transients e.g. overtaking

Vehicle and powertrain characteristics

Vehicle
- Renault Scenic – C-segment
- 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)
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

UBIA – 28 November 2019
Robust NOx control achieved

Also on a renewable fuel which offers reduced CO₂ emissions on lifecycle basis
All aftertreatment components contribute to NOx control

- City driving: LNT and close coupled SCR+SDPF
- Motorway driving: underfloor SCR required to secure robust emissions control
Robust NOx control in the city directly after cold-start

- 80% improvement due to LNT regeneration stabilisation and active thermal management
- Near-zero emissions in the city after the cold-start phase

Transport for London cycle

![Graph showing cumulative NOx emissions over time with initial and refined calibrations. The refined calibration results in 80% improvement from 216 mg/km to 47 mg/km.]

UBIA – 28 November 2019
PN and PM controlled by SDPF under all driving conditions

PN of all tests has order of magnitude between $10^9$ and $10^{10}$ #/km

sub-23nm PN (10nm CPC)
CO emission well within standards on WLTC and RDE

- Remains below 50 mg/km on WLTC and RDE
- Increases on TfL due to impact of thermal management (optimisation was outside programme scope)
THC emission well within standards on WLTC and RDE

- THC+NOx remains below 50 mg/km on WLTC and RDE
- Increases on TfL due to impact of thermal management (optimisation was outside programme scope)
Other approaches are available to achieve low NOx

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

3. G. Avolio, et al.; “Super Clean Electrified Diesel: Towards Real NOx Emissions below 35 mg/km”, 27th Aachen Colloquium, 2018
Diesel achieves similar NOx emissions as gasoline

Euro 6d(-TEMP) diesel expected to have improved engine-out & dual-SCR
Content

- EU Real-driving Emissions legislation
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- AECC ultra-low emissions diesel demonstrator
- Gasoline PN emissions
RDE has significantly improved GDI PN emissions

On-road emissions of Euro 6d(-TEMP) cars are well within standards

Trend is confirmed by 3rd party testing

Source:
- ACEA/JAMA Euro 6d(-TEMP) PEMS data consulted 19 November 2019
- pre-RDE emissions factors from B. Giechaskiel, Int. J. Environ. Res. Public Health, 2018

Source: Emissions Analytics
Light-duty gasoline emissions control technology evolution

Single Three-Way Catalyst for Euro 6a/b

- Three-Way Catalyst (TWC)
  - Source: Volvo

Introduction of Gasoline Particulate Filter on cars with direct injection and integration with Three-Way Catalyst for Euro 6d(-TEMP)

- TWC
- Gasoline Particulate Filter (GPF)
  - Source: PSA

- Single Three-Way Catalyst for Euro 6a/b
  - Source: VW
  - Source: Audi

- 2x TWC
  - Source: Opel

Source: Audi
Conclusions

- RDE requirements have ensured better control of NOx & PN emissions under most EU driving conditions on both diesel and gasoline vehicles – these Euro 6d(-TEMP) cars are on the road today.

- AECC’s diesel demo car shows that diesel NOx emissions can be kept at a very low level in a consistent way, over a wide range of driving conditions.

- This is achieved by combining existing catalyst technologies with improved engine and aftertreatment control functions supported by hybrid technology.
Diesel Information Hub

https://dieselinformation.aecc.eu
Real-world NOx emissions gap is issue of pre-RDE diesels
THANK YOU!

www.aecc.eu
dieselinformation.aecc.eu