AVL POWERTRAIN ENGINEERING
TECHDAY #4

Emissions legislation update from WLTP/RDE to EU7
EMISSION REGULATION UPDATE CONTENT

- Introduction
- Update European Union RDE Status
- Update European Union WLTP
- Global Overview
- Update China
- Outlook
- AVL Legislation Services
Introduction

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# MOTIVATION FOR NEW REGULATIONS
**GAP BETWEEN TYPE APPROVAL & REAL LIFE**

<table>
<thead>
<tr>
<th>Year</th>
<th>NOx Real life (mg/km)</th>
<th>NOx Diesel limit in lab (mg/km)</th>
<th>Gap between (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>1000</td>
<td>500</td>
<td>100%</td>
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<tr>
<td>2005</td>
<td>800</td>
<td>250</td>
<td>220%</td>
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<td>2010</td>
<td>800</td>
<td>150</td>
<td>345%</td>
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<tr>
<td>2015</td>
<td>600</td>
<td>50</td>
<td>650%</td>
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</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>CO2 Norm emissions (g/km)</th>
<th>CO2 Real life (g/km)</th>
<th>Gap between (%)</th>
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</thead>
<tbody>
<tr>
<td>2000</td>
<td>172</td>
<td>184</td>
<td>7%</td>
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<tr>
<td>2005</td>
<td>163</td>
<td>182</td>
<td>12%</td>
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<tr>
<td>2010</td>
<td>140</td>
<td>168</td>
<td>20%</td>
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<tr>
<td>2015</td>
<td>120</td>
<td>188</td>
<td>38%</td>
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This is only a symbolic presentation of the measurement data from ICCT. Nevertheless, how accurate and representative this data are, it represents the motivation of the EU rule making for a new European legislation process. Data Source: ICCT International Council on Clean Transportation 2014.
**REGULATION – GOAL: TO CLOSE THE GAP**

Today pollutant emissions are in average app. 7 times (Diesel NOx) higher on the road than in the lab.

<table>
<thead>
<tr>
<th>Measures:</th>
<th>Targets:</th>
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<tr>
<td>RDE PEMS testing</td>
<td>Close the gap between lab and real life pollutant emission limits</td>
</tr>
<tr>
<td>Euro-6 Limits</td>
<td>Further reducing NOx and PN emissions</td>
</tr>
<tr>
<td>130 $\rightarrow$ 95 gCO$_2$/km</td>
<td>Further reducing CO$_2$ and fuel consumption targets</td>
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<tr>
<td>WLTP</td>
<td>Close the gap between norm and real life CO$_2$ and fuel consumption</td>
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Today CO2 emissions and fuel consumption are in average app. 40% higher on the road than the declared norm values.
EMISSION TESTING TRENDS

Laboratory Certification + OBD + COP + ISC

Real Driving Emissions (Not to exceed limits)

PEMS

RDE used to chase “Defeat Devices”

only Gasoline

only Gasoline
HOW REGULATION COMPLEXITY CHANGED

Example: EU Passenger Cars: Euro 0 to Euro 6d

In Annex 8 of this Regulation, references to Annex 4 shall be understood as reference to Appendix 4 of Annex I of this Regulation. (Quotation from UNR 83)
### NEW CHARACTERISTIC OF LEGISLATIVE DEVELOPMENT

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<tr>
<td>Limits</td>
<td>Euro 6b</td>
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<td>Euro 6d temp</td>
<td>Euro 6d</td>
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<td>Euro 7</td>
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<tr>
<td>CO₂</td>
<td>130 g/km CO₂</td>
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<td>Tech. Reg</td>
<td>UN-ECE Reg. 83</td>
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<tr>
<td>RDE</td>
<td>Monitor</td>
<td>NOx 2.1, PN 1.5</td>
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<td>RDE CF NOx &lt; 1.5, CF PN 1.5</td>
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**04.2016** RDE Monitoring

**09.2017** WLTP + RDE with CF-temp.

**09.2019** New EVAP Procedure

**01.2020** RDE with final CF

- **Dec. 2017 RDE Package 4**
  - In Service Conformity, Member State Surveillance

- **3Q 2017 revised evaporative emission testing**
  - Canister aging, test procedures, sealed tank systems for hybrids, ...

- **Jan. 2017 Guidance on AES and Defeat Devices**
  - Documentation of AES, engine protection, impact assessment, defeat device testing, ...

- **Dec. 2016 RDE Package 3**
  - PN Limit, Cold start, Hybrids

- **Feb. 2016 RDE Package 2**
  - NOx Limit, Test Boundary Conditions

- **2015 RDE Package 1**
  - Decision on PEMS, Monitoring from 2016

No lead time for engineering / Last-Minute amendments
Introduction

Update European Union RDE Status

- Update European Union WLTP
- Global Overview
- Update China
- Outlook
- AVL Legislation Services
RDE REGULATION STATUS

Status is based on

- Regulation (EU) 2017/1151 (implementation of WLTP in EU, incl. RDE 1\textsuperscript{st} and 2\textsuperscript{nd} package)
- Regulation (EU) 2017/1154 (3\textsuperscript{rd} RDE package)
- Regulation (EU) 2017/1347 (Correcting Act to (EU) 2017/1151)
- EU RDE 4 working group meetings, Brussels, January to September 2017

Amendments are still possible.

Status September 2017
Where should the RDE test procedure be applied?

- **Initial type approval test**: basically in parallel to the type 1 test (WLTP)
- **In-service-conformity**: basically in parallel to the type 1 test
- **Member State surveillance testing**: to be defined at a later stage since only to be applied after introduction of mandatory NTE emission limits
- **Conformity of production test**: no RDE testing is foreseen for the moment
RDE IMPLEMENTATION – 4 PACKAGES (1+2)

The Commission is planning to adopt the RDE legislation in four legislative packages:

1st package
(published March 31, 2016)

- Test procedure for gaseous pollutants
- Instrument specifications
- Trip requirements
- Non-dynamic boundary conditions
- Trip evaluation with evaluation tools EMROAD and CLEAR

2nd package
(published April 20, 2016)

- Temporary and final conformity factor NOₓ
- Implementation dates for not-to-exceed limits for NOₓ
- Complementary dynamic boundary conditions
  - v*a_pos (acceleration x speed)
  - Relative positive acceleration
  - Positive elevation gain

RDE IMPLEMENTATION – 4 PACKAGES (3+4)

The Commission is planning to adopt the RDE legislation in four legislative packages:

3\textsuperscript{rd} package
(published July 7, 2017)

- Test procedure for particulate number
- CF for PN
- Instrument specifications (PN)
- Cold start
- Special provisions for hybrids
- Regeneration
- Special provisions for small and ultra-small volume manufacturers
- Special provisions for vehicles with speed limiters

4\textsuperscript{th} package
(draft Q4 2017?)

- In-service compliance
- Administrative rules
- Technical rules
- Transfer functions?
- Review of:
  - Hybrid evaluation
  - Evaluation methods
  - Conformity factors

Source: “Real Driving Emissions (RDE) Portable Emission Measurement Systems (PEMS) Particle Number (PN) Implementing PN-PEMS for RDE procedures”, B. Giesachkiel, 3\textsuperscript{rd} International Conference Real Driving Emissions, October 2015, Berlin
**SUMMARY**

(EU) 2017/1151: published 07.07.2017

WLTP 2\textsuperscript{nd} Act: first working draft available, implementation tbd

RDE NO\textsubscript{x} CF = 2.1/1.5, included in WLTP 1\textsuperscript{st} Act

<table>
<thead>
<tr>
<th>NO\textsubscript{x} CF</th>
<th>New type approval</th>
<th>All new registrations</th>
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</thead>
<tbody>
<tr>
<td>M1, M2, N1 class 1</td>
<td>1 September 2017 / 1 January 2020</td>
<td>1 September 2019 / 1 January 2021</td>
</tr>
<tr>
<td>N1 class II and III, N2</td>
<td>1 September 2018 / 1 January 2021</td>
<td>1 September 2020 / 1 January 2022</td>
</tr>
</tbody>
</table>

RDE PN CF = 1.5, Regulation (EU) 2017/1154 (RDE package 3)

<table>
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<th>PN CF</th>
<th>New type approval</th>
<th>All new registrations</th>
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<tbody>
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<td>M1, M2, N1 class 1</td>
<td>1 September 2017</td>
<td>1 September 2018</td>
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<tr>
<td>N1 class II and III, N2</td>
<td>1 September 2018</td>
<td>1 September 2019</td>
</tr>
</tbody>
</table>

CO: measurement and reporting
RDE METHODOLOGY

- Trip requirements
  - Urban, rural, motorway
  - Min. and max. speed

- Non-dynamic boundary conditions
  - Temperature
  - Altitude

- Dynamic boundary conditions
  - \( v^\text{apos} \)
  - RPA

- Trip normality, weighting
  - EMROAD
  - CLEAR

Final emissions result, comparison with limit

\[ CE = CF \times \text{Euro} \]

- CF
  - 1.5

- \( CE \)
RDE – TRIP REQUIREMENTS

3 operational parts, min. 16 km each, start with urban operation:

- **Urban** operation: vehicle speeds **up to 60 km/h**, 
- **Rural** operation: vehicle speeds **between 60 and 90 km/h**, 
- **Motorway** operation: speeds **above 90 km/h**

Approximately ( +/- 10%) 
1/3 of distance per part, urban part: min. 29%

Trip duration: 90-120 min
Min. 5 min > 100 km/h
At least once > 110 km/h
Max. 145 km/h (max. 160 km/h for 3% of motorway driving time)

\[ |\Delta \text{ Start-End}| \leq 100 \text{ m} \]

Positive cumulative altitude gain over complete trip and urban part < 1200 m/100 km

Cold & at least one hot start test required per PEMS test family

Example for an RDE route
NON-DYNAMIC BOUNDARY CONDITIONS

- Non-dynamic boundary conditions: altitude, temperature
- Moderate and extended conditions
- Time interval of extended conditions: emissions divided by factor 1.6
- Part or total test outside extended conditions: trip is invalid

**Altitude**

- Trip invalid
- Extended (div. by 1.6): 1,300 m
- Moderate: 700 m

**Temperature**

- Trip invalid
- Extended (div. by 1.6): 35 °C
- Moderate: 30 °C
- Extended (div. by 1.6): -2 °C, 30 – 35 °C


*N1 class II&III, N2: one year later*
RDE PACKAGE 4
ISSUES UNDER DISCUSSION

- RDE testing during ISC, introducing the possibility for independent testing by third parties
- Dealing with issues related to LCVs, multistage and special purpose vehicles
- Transfer functions
- Gasoline fuel issue
- Guidance documents

Reviews:

- Evaluation methods (EMROAD & CLEAR)
- More representative method for testing hybrid vehicles
- Review of uncertainty margins for NO\textsubscript{x} (CF)
- Possible review of the cold start analysis
- Review of Ki factors
RDE 4 – IN-SERVICE CONFORMITY (ISC)

New ISC procedure

OEM

2. WLTP Tests (all PEMS families) + RDE tests voluntary by manufacturer

3. (WLTP)+RDE Test % of families
   By GTAA
   By accredited lab

5. Investigation of causes
   Possible Remedial Measures
   By GTAA, OEMS

TAA

3rd Party

1. Validated surveillance data

4. Independent WLTP + RDE Tests
   by accredited lab

INFO for ISC

RDE 4 ISC

6. Publicly Available Report

Draft expected for Q4/2017

GTAA: granting type approval authority

EC, 05.-06.07.2017
RDE 4 – REVIEW OF EVALUATION METHODS

- Currently two evaluation methods are used
  - EMROAD (Moving Average Windows)
  - CLEAR (Power Binning Method)

- Purpose of evaluation methods
  - Evaluation of trip validity
  - Trip normalization

- Goals:
  - Complete review of methods
  - Decision on one method

Draft expected for Q4/2017
RDE 4 – REVIEW OF UNCERTAINTY MARGINS

- The “final” conformity factors for NO\textsubscript{x} and PN of 1.5 are defined as “1 + margin”, with the margin for measurement uncertainties currently = 0.5 for NO\textsubscript{x} and PN.

- The margins are subject to an annual review to account for the improvement of measurement equipment.

- The goal announced by the responsible European Commissioner Elzbieta Bienkowska was to reach a CF of 1.0 by 2023.

- The European Parliament called for a CF of 1.0 by 2021 (see below)\(^1\)

- Current discussions:
  - No reduction of PN margin planned during this annual review
  - Reduction of NO\textsubscript{x} margin planned (new value to be defined)

\(^1\)Inquiry into emission measurements in the automotive sector: European Parliament recommendation of 4 April 2017 to the Council and the Commission following the inquiry into emission measurements in the automotive sector
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EMISSION REGULATION UPDATE

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The WLTP test procedure is transposed into European legislation by a new Implementing Regulation (EU) 2017/1151 (WLTP 1st Act).

The new Regulation (EU) 2017/1151 (WLTP 1st Act) will be mandatory from:

<table>
<thead>
<tr>
<th>Model Class</th>
<th>New type approval</th>
<th>All new registrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1, M2, N1 class I</td>
<td>1 September 2017</td>
<td>1 September 2018</td>
</tr>
<tr>
<td>N1 class II and III, N2</td>
<td>1 September 2018</td>
<td>1 September 2019</td>
</tr>
</tbody>
</table>

Currently under discussion: WLTP 2nd Act

- Correction of test flexibilities (test speed and distance, driving trace violations)
- Transparency of test parameters to enable third party testing
- Implementation of recent changes to gtr15 (WLTP on UN ECE level)
- Implementation of new EVAP gtr into EU Regulation
- On-board fuel consumption monitoring
- Draft expected for Q4 2017
Common technical requirements for type approval

Implementation measures;
Alignment with ECE Regulations:
Basis ECE Regulations + additional requirements
Will be repealed

Commission Regulation (EU) 2017/1151 (WLTP 1st Act)


Currently under discussion – RDE 4th package
Currently under discussion – WLTP 2nd Act

New ECE Rxxx under consideration

ECE R83
Exhaust
Emissions

ECE R85
Net power and maximum 30 min power of electric drive trains

ECE R24
Smoke Opacity

ECE R103
Replacement Pollution Control Devices as separate Technical Unit

gtr 15 WLTP
## WLTP IN EU – CURRENT STATUS

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Dyno</th>
<th>Automation</th>
<th>CVS</th>
<th>Emission Bench</th>
<th>PTV</th>
<th>PN</th>
<th>Instruments</th>
<th>SHED</th>
<th>Climatic Chamber</th>
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<tbody>
<tr>
<td>I</td>
<td>Average exhaust emission after a cold start</td>
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<td>II</td>
<td>CO concentration at idling speed</td>
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<td>III</td>
<td>Emissions of crankcase noises</td>
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<td>IV</td>
<td>Evaporation emissions (SHED - Test)</td>
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<td>V</td>
<td>Durability of anti-pollution devices</td>
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<td>VI</td>
<td>Low ambient temperature (-7°C) exhaust emissions</td>
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<td>CO2 and Fuel consumption</td>
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**WLTP 1st Act**
- UN-ECE R-83/ transitional provisions for EU
- 01.09.2017 WLTP
- 01.09.2019
- UN-ECE R-24

**WLTP 2nd Act**
- All tests based on new WLTP procedure
- 01.09.2019

**WLTP future developments**
- 01.09.2017 WLTP
EURO 6b, 6c & 6d IMPLEMENTATION – PASSENGER CARS

Status according to Regulation (EU) 2017/1151, (EU) 2017/1154, and (EU) 2017/1347, updates will be made depending on rulemaking progress.

Mandatory dates:
- New type approval
- All new registrations
- Last date of registration

*Double testing under certain conditions
** WLTP based targets will be defined based on 2020 NEDC CO₂ values.
WLTP based targets will have comparable stringency to NEDC based 95 g/km.

*Phase-in 95 g/km (NEDC based)**

Phase-in 130 g/km

130 g/km

95 g/km (NEDC based)**

WLTP CO₂ converted to NEDC CO₂ (CO₂MPAS)*

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TA: Character
BA | AA | W | AD | AG | BG | AJ | ZA, ZD, ZG, ZJ: Euro 6c, 6d-TEMP, 6d NEDC: LDR: 31/08/2018

RDE: NOx monitoring, PN: 1.5
RDE: NOx monitoring, PN: 1.5
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RDE: NOx monitoring, PN: 1.5
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Phase-in 130 g/km
130 g/km

95 g/km (NEDC based)**

WLTP CO₂ converted to NEDC CO₂ (CO₂MPAS)*
EU CO₂ EMISSIONS – TRANSITION FROM NEDC TO WLTP

Until 2020:

- conversion of WLTP test results to NEDC values → CO₂MPAS simulation tool or double testing under certain conditions

From 2021:

- WLTP based targets
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PASSENGER CAR EMISSION STANDARDS – 2018
PASSENGER CAR EMISSION STANDARDS – EXPECTED 2023

General view

Tier 3 / LEV III
Tier 2 / LEV II
Euro 4 or equivalent
Euro 6
PROCONVE L8
Euro 6 or equivalent

Euro 5 or equivalent

China 6b
PPNLT
Euro 6 or equivalent
Euro 4 or equivalent or prior
Euro 6 or equivalent
WORLD-WIDE EMISSION LEGISLATION FOR PASSENGER CARS

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<tr>
<td>EU</td>
<td>Euro 5</td>
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<td>Tier 2</td>
<td>Tier 3 (Phase-in)</td>
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<td>CD₂ (2020/2021)</td>
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<td>GHG &amp; FC</td>
<td>LEV III (Phase-in)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Korea</td>
<td>LEV II/Euro 6</td>
<td></td>
<td></td>
<td></td>
<td>LEV III gasoline/Euro 6 Diesel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>Phase 4</td>
<td></td>
<td></td>
<td></td>
<td>Phase 5</td>
<td>Phase 6a</td>
<td>Phase 6b</td>
<td>Stage 3: 2012-2016</td>
<td>Stage 4: Fuel Economy (Phase-in 2016-2020)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China Beijing</td>
<td>Phase 5 gasoline ¹</td>
<td></td>
<td></td>
<td></td>
<td>Phase 5 gasoline ¹</td>
<td>Phase 6</td>
<td></td>
<td>Stage 3</td>
<td>Stage 4: Fuel Economy (Phase-in 2016-2020)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>BS III</td>
<td></td>
<td></td>
<td></td>
<td>BS IV</td>
<td>Fuel Efficiency</td>
<td></td>
<td>BS VI</td>
<td>BS VI</td>
<td>Fuel Efficiency</td>
<td>Fuel Efficiency</td>
<td>BS VI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>India Megacities</td>
<td>BS IV</td>
<td></td>
<td></td>
<td></td>
<td>BS IV</td>
<td>Fuel Efficiency</td>
<td></td>
<td>BS VI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CO₂/FUEL CONSUMPTION TARGETS FOR PASSENGER CARS

EU 2012-2015 and 2020-2022:
< 50 g CO₂/km
March 2015 for supercredits

EU 2025: 69-78* EP

*Proposed Env. Committee EP April 2013

RDE IMPLEMENTATION WORLDWIDE

- **EU**: Monitoring: 04/2016
  Conformity factors: 09/2017
- **South Korea**: 09/2017 (diesel only)
- **Japan**: discussions: diesel only (NOx), introduction 2022
- **China**: China 6
  Monitoring from 07/2020
  CFs from 07/2023
- **USA (CARB)**: PEMS for detection of defeat devices
- **Brazil**: discussions
  2022: monitoring?
  2024/2027: CFs?

Status: 07/2017
WLTP IMPLEMENTATION WORLDWIDE

- **EU**: 09/2017
- **South Korea**: 09/2017 (diesel only)
- **Japan**: 10/2018, w/o extra high speed phase
- **Taiwan**: 09/2019 (alternatively: US cycles)
- **India**: BS VI: Current cycle (NEDC 90) remains
- **China**: China 6 07/2020

*Italics: draft/proposed; dates for new type approval*
Introduction

Update European Union RDE Status

Update European Union WLTP

Global Overview

Update China

Outlook

AVL Legislation Services
China 6 implementation

<table>
<thead>
<tr>
<th>New types</th>
<th>New vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>6a</td>
<td>July 1, 2020</td>
</tr>
<tr>
<td>6b</td>
<td>July 1, 2023</td>
</tr>
</tbody>
</table>

Regions/cities (e.g. Beijing) may enforce China 6a or 6b earlier

Test procedure: WLTP 4 phases, Vehicle Class 3
- Significantly more stringent than Euro 6d
- Low temperature requirements
- Evaporative requirements
- Extended RDE
## CHINA 6 REGULATION TYPE I (EXHAUST EMISSIONS)

Cycle: WLTC 4 phases; Class 3

Limits (fuel neutral):

<table>
<thead>
<tr>
<th></th>
<th>CO (mg/km)</th>
<th>THC (#/km)</th>
<th>NMHC (mg/km)</th>
<th>THC+NOₓ (mg/km)</th>
<th>NOₓ (mg/km)</th>
<th>PM (mg)</th>
<th>PN (mg)</th>
<th>N₂O (mg/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>China 6a</strong></td>
<td>700</td>
<td>100</td>
<td>68</td>
<td>-</td>
<td>60</td>
<td>4.5</td>
<td>6x10¹¹</td>
<td>20</td>
</tr>
<tr>
<td><strong>China 6b</strong></td>
<td>500</td>
<td>50</td>
<td>35</td>
<td>-</td>
<td>35</td>
<td>3.0</td>
<td>6x10¹¹</td>
<td>20</td>
</tr>
<tr>
<td><strong>Euro 6d</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Euro 6d SI</strong></td>
<td>1000</td>
<td>100</td>
<td>68</td>
<td>-</td>
<td>60</td>
<td>4.5</td>
<td>6x10¹¹</td>
<td>-</td>
</tr>
<tr>
<td><strong>Euro 6d CI</strong></td>
<td>500</td>
<td>-</td>
<td>-</td>
<td>170</td>
<td>80</td>
<td>4.5</td>
<td>6x10¹¹</td>
<td>-</td>
</tr>
<tr>
<td><strong>Compared to Euro 6d</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>China 6b/SI</strong></td>
<td>-50%</td>
<td>-50%</td>
<td>-49%</td>
<td>-</td>
<td>-42%</td>
<td>-33%</td>
<td>0 China only</td>
<td></td>
</tr>
<tr>
<td><strong>China 6b/CI</strong></td>
<td>0</td>
<td>China only</td>
<td>China only</td>
<td>-59%*</td>
<td>-56%</td>
<td>-33%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Compared to the sum of China 6b THC and NOₓ limit
CHINA 6 REGULATION TYPE II (RDE)

- CFs mandatory with 6b limits

<table>
<thead>
<tr>
<th>CF</th>
<th>NOx</th>
<th>PN</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Euro 6d</td>
<td>China 6b</td>
<td>Euro 6d</td>
</tr>
<tr>
<td>Gasoline</td>
<td>1.5</td>
<td>2.1</td>
<td>1.5</td>
</tr>
<tr>
<td>Diesel</td>
<td>1.5</td>
<td>2.1</td>
<td>1.5</td>
</tr>
</tbody>
</table>

- RDE requires measurement and recording of CO emission
- Before 01 July 2022: reevaluation of CFs planned
- Before 01 July 2023: monitoring and reporting of results

- Compared to EU: additional extended ambient conditions (altitude)

<table>
<thead>
<tr>
<th>Extended conditions correction factor</th>
<th>700-1,300m</th>
<th>1,300-2,400m</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>China</td>
<td>EU</td>
</tr>
<tr>
<td>Gasoline</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Diesel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CHINA 6 REGULATION TYPE VI (-7°C TEST)

- Limits both for gasoline and diesel
- Cycle: low and medium phases of WLTP

<table>
<thead>
<tr>
<th></th>
<th>CO</th>
<th>THC</th>
<th>NOₓ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limits China 6 (g/km)</td>
<td>10.0</td>
<td>1.20</td>
<td>0.25</td>
</tr>
<tr>
<td>Euro 6d (gasoline) (g/km)</td>
<td>15.0</td>
<td>1.8</td>
<td>-</td>
</tr>
<tr>
<td>Euro 6d (diesel)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Comparison to Euro 6d

<table>
<thead>
<tr>
<th></th>
<th>CO</th>
<th>THC</th>
<th>NOₓ</th>
</tr>
</thead>
<tbody>
<tr>
<td>China 6 to Euro 6d (gasoline)</td>
<td>-33%</td>
<td>-33%</td>
<td>China only</td>
</tr>
<tr>
<td>China 6 to Euro 6d (diesel)</td>
<td>China only</td>
<td>China only</td>
<td>China only</td>
</tr>
</tbody>
</table>
The regulation applies to car makers that produce or import more than 30 000 conventional vehicles annually. If automakers fail to achieve the quotas, they will either have to buy credits from other companies or face a fine.

<table>
<thead>
<tr>
<th>Year</th>
<th>Quota</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>10%</td>
</tr>
<tr>
<td>2020</td>
<td>12%</td>
</tr>
<tr>
<td>2020+</td>
<td>tbd by MIIT</td>
</tr>
</tbody>
</table>

### CHINA NEV REQUIREMENTS


<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Standard model points</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure electric passenger car</td>
<td>0.012×R+0.8</td>
<td>(1) R is the electric vehicle driving range (working method), the unit is km.</td>
</tr>
<tr>
<td>Plug-in hybrid passenger cars</td>
<td>2</td>
<td>(2) P is the rated power of the fuel cell system, in kW.</td>
</tr>
<tr>
<td>Fuel cell passenger car</td>
<td>0.16×P</td>
<td>(3) The upper limit of the standard model is 5 points.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4) vehicle model calculation results by the principle of rounding to retain two decimal places.</td>
</tr>
</tbody>
</table>
AVL POWERTRAIN ENGINEERING TECHDAY #4
EMISSION REGULATION UPDATE

- Introduction
- Update European Union RDE Status
- Update European Union WLTP
- Global Overview
- Update China

- Outlook
- AVL Legislation Services
BASE FOR AVL ASSUMPTIONS FOR EURO 7

Update -7°C Test:

Vehicles: ICE, OVC-HEV, NOVC-HEV
Pollutants: THC, NOx, CO, CO2 and PN
Auxillary Devices On: Heater, defrost and light

European Parliament-Recommendation (April 2017):

16. ... considers that for particulate matter **PEMS technology** should be able to account for **particles** whose size is **smaller than 23 nanometres** and that are the most dangerous to public health;

73. Calls on the Commission to **review the emissions limits** set out in Annex I to Regulation (EC) No 715/2007 with a view to **improving air quality** in the Union and to **achieving the Union ambient air quality limits** as well as the **WHO recommended levels**, and to come forward by **2025** at the latest with proposals, as appropriate, for new **technology-neutral Euro 7 emission limits** applicable for all M1 and N1 vehicles placed on the Union market;

Source: “Inquiry into emission measurements in the automotive sector – European Parliament recommendation of 4 April 2017 to the Council and the Commission following the inquiry into emission measurements in the automotive sector (2016/2908(RSP))”

Progress Report Low and Realistic Winter Temperature TF WLTP 20th-September 2017C. JRC, Astorga
AIR QUALITY
EU DIRECTIVE & WHO GUIDELINE

Limited substances within Annex XI of EU Air Quality Directive 2008/50/EC:
PM$_{2.5}$, SO$_2$, NO$_2$, PM10, Lead, CO, Benzene, Ozone, Arsenic, Cadmium, Nickel, Polycyclic Aromatic Hydrocarbons

Comparison of limit values for different substances (bold = WHO more stringent)

<table>
<thead>
<tr>
<th>Substance</th>
<th>Limit values (EU)$^1$</th>
<th>Limit values (WHO AQG)$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozone</td>
<td>120 µg/m$^3$ 8-hour mean$^a$</td>
<td>100 µg/m$^3$ 8-hour mean</td>
</tr>
<tr>
<td>SO$_2$</td>
<td>350 µg/m$^3$ 1-hour mean</td>
<td>500 µg/m$^3$ 10-minute mean</td>
</tr>
<tr>
<td></td>
<td>125 µg/m$^3$ 24-hour mean</td>
<td>20 µg/m$^3$ 24-hour mean</td>
</tr>
<tr>
<td>NO$_2$</td>
<td>200 µg/m$^3$ 1-hour mean</td>
<td>200 µg/m$^3$ 1-hour mean</td>
</tr>
<tr>
<td></td>
<td>40 µg/m$^3$ annual mean</td>
<td>40 µg/m$^3$ annual mean</td>
</tr>
<tr>
<td>Benzene</td>
<td>5 µg/m$^3$ annual mean</td>
<td>5 µg/m$^3$ annual mean</td>
</tr>
<tr>
<td>CO</td>
<td>10 mg/m$^3$ 8-hour mean</td>
<td>10 mg/m$^3$ 8-hour mean</td>
</tr>
<tr>
<td>Pb</td>
<td>0.5 µg/m$^3$ annual mean</td>
<td>-</td>
</tr>
<tr>
<td>PM$_{10}$</td>
<td>50 µg/m$^3$ 24-hour mean</td>
<td>50 µg/m$^3$ 24-hour mean</td>
</tr>
<tr>
<td></td>
<td>40 µg/m$^3$ annual mean</td>
<td>20 µg/m$^3$ annual mean</td>
</tr>
<tr>
<td>PM$_{2.5}$</td>
<td>25$^b$ (20$^c$) µg/m$^3$ annual mean</td>
<td>10 µg/m$^3$ annual mean</td>
</tr>
</tbody>
</table>

$^1$ EU DIRECTIVE 2008/50/EC
$^2$ WHO Air quality guidelines, Global update 2005
$^a$ Longterm objective
$^b$ Stage 1 - Date by which limit value is to be met: 1 January 2015
$^c$ Stage 2 - Date by which limit value is to be met: 1 January 2020

PM$_{10}$ concentration.
Red: above EU limit value
### EU: POSSIBLE FURTHER DEVELOPMENT (I)

<table>
<thead>
<tr>
<th>Topic</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel neutral limits</td>
<td>same limit for gasoline &amp; diesel</td>
</tr>
<tr>
<td>( \text{NO}_x, \text{NO}_2 )</td>
<td>Reduction ( \text{NO}_x ) limit, implementation of ( \text{NO}_2 ) limit</td>
</tr>
<tr>
<td>( \text{NH}_3 )</td>
<td>Implementation of ( \text{NH}_3 ) limit, SCR technology, HD applications already limited</td>
</tr>
<tr>
<td>( \text{PN} )</td>
<td>Revision of measurement procedure, including of ultrafine particles (size &gt; 10 nm)</td>
</tr>
<tr>
<td>Low temperature emissions</td>
<td>Emission limits for PI and CI vehicles (- 7°C), additional components</td>
</tr>
</tbody>
</table>
## EU: POSSIBLE FURTHER DEVELOPMENT (II)

<table>
<thead>
<tr>
<th>Topic</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDE</td>
<td>Reduction of CF (Target CF=1 in 2023) General evaluation</td>
</tr>
<tr>
<td>CO\textsubscript{2}</td>
<td>Definition of 2025 targets, proposal November 2017 awaited</td>
</tr>
<tr>
<td>CH\textsubscript{4}, N\textsubscript{2}O</td>
<td>Limitation</td>
</tr>
<tr>
<td>CO\textsubscript{2} GHG</td>
<td>Consideration of upstream CO\textsubscript{2} emissions – long term</td>
</tr>
<tr>
<td>Air Quality</td>
<td>Extension of Low Emission Zones and access restrictions</td>
</tr>
<tr>
<td>Electrification</td>
<td>Promotion of PHEVs and EVs</td>
</tr>
</tbody>
</table>
## DERIVATION OF EURO 7-SCENARIO

### COMPARISON OF STANDARDS & ASSUMPTION

<table>
<thead>
<tr>
<th>Dura-bility (km)</th>
<th>Test Cycle</th>
<th>NMOG+ NOx (mg/km)</th>
<th>THC (mg/km)</th>
<th>NOx (mg/km)</th>
<th>NO2 (mg/km)</th>
<th>THC+ NOx (mg/km)</th>
<th>NMHC (mg/km)</th>
<th>CO (mg/km)</th>
<th>HCHO (mg/km)</th>
<th>PM (#/km)</th>
<th>N2O (mg/km)</th>
<th>CH4 (mg/km)</th>
<th>NH3 (ppm)</th>
<th>RDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SULEV 30</td>
<td>241,402</td>
<td>FTP 75</td>
<td>18.64</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>621</td>
<td>18.64</td>
<td>6.21</td>
<td>2025+</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>SULEV 20</td>
<td></td>
<td></td>
<td>12.43</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>2025+</td>
<td>6.21</td>
<td>-</td>
<td>6.21</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>China 6b</td>
<td>200,000</td>
<td>WLTP</td>
<td>-</td>
<td>50</td>
<td>35</td>
<td>35</td>
<td>500</td>
<td>-</td>
<td>3.0</td>
<td>6x10^11</td>
<td>20</td>
<td>-</td>
<td>CF=2.1</td>
<td></td>
</tr>
</tbody>
</table>
  - 7°C-Test: fuel neutral; limits for CO, THC and NOx via low and medium phases of WLTP
  - RDE extended ambient conditions: altitude up to 2,400m

| Euro 6d SI       | 160,000    | WLTP              | -           | 100         | 60          | -               | 68           | 1000        | -           | 4.5       | 6x10^11     | -          | -         | CF=1.5 |
| Euro 6d CI       |            | WLTP              | -           | -           | 80          | 170             | -            | 500         | -           | 4.5       | 6x10^11     | -          | -         | CF=1.5 |

**WLTP GTR15**
- Sampling and analysis methods for NH3, N2O, ethanol, formaldehyde and acetaldehyde (if applicable)

| Euro 7*          | 200,000    | WLTP              | -           | 50          | 35          | 20              | -            | 35          | 500         | -         | 3.0         | 6x10^11   | ?         | 10    |
  - 7°C-Test: fuel neutral; limits for CO, THC, NOx, PN and CO2 via low and medium phases of WLTP
  - RDE revised procedure and normalization tools
  - PN: > 10 nm

*AVL Assumption
Introduction

Update European Union RDE Status

Update European Union WLTP

Global Overview

Update China

Outlook

AVL Legislation Services
AVL EMISSION LEGISLATION WORLD

AVL Emission Report
Studies & Forecasts
Consulting

Newsletter
Training

Central contact E-mail: emrep@avl.com
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Current and future regulations

Comprehensive summary which keeps up with ever changing regulations

Homepage: wwwavl.com/legislation-services (incl. EmRep-Demoversion)
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