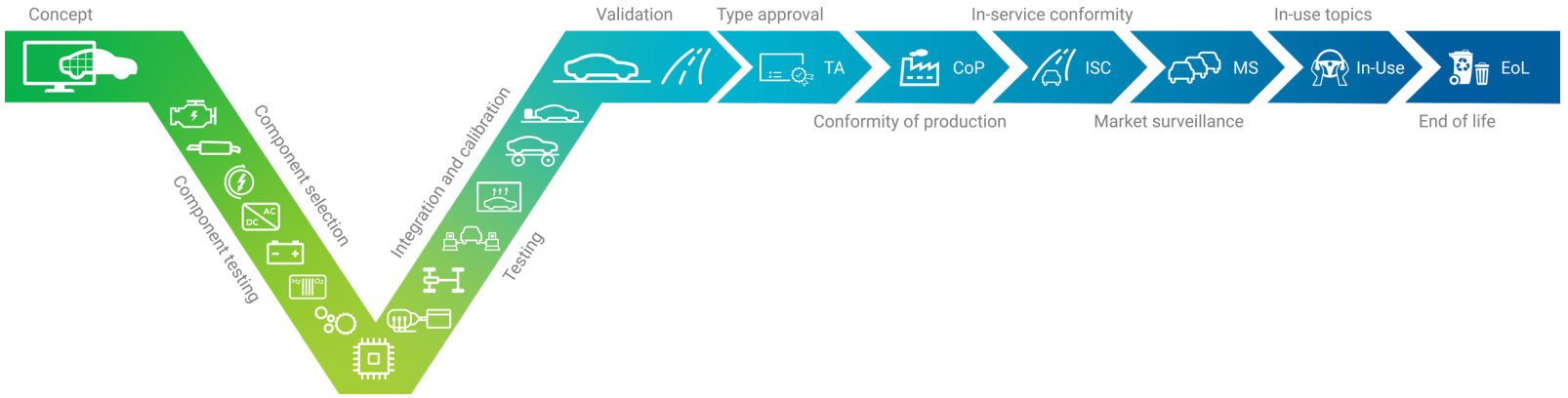
WHITEPAPER

Forthcoming Emissions Challenges: Euro 7, China 7, and USA

Development, Calibration, Certification, On-Board Monitoring

Meeting Emissions Targets Throughout a Vehicle's Lifetime

Forthcoming emissions challenges Euro 7, China 7, and USA



Emissions-related testing starts at vehicle development and is an ongoing part of a vehicle's usage until its end of life.

Numerous tests, like WLTP, RDE, and low temperature, lead up to type approval (TA). Conformity of Production (CoP) ensures vehicles comply with legislative targets. In-service conformity (ISC) tests and market surveillance (MS) validate a vehicle's emissions compliance in real world operation.

Each vehicle is already checked by on-board diagnostics (OBD) and regular maintenance and service (MaS) activities.

Forthcoming legislations (Euro 7, China 7, changes in the USA) are increasing requirements:
On-board monitoring (OBM), anti-tampering, and brake and tire emissions are to be tested in a wide range of ambient conditions.

Even with a softened Euro 7 legislation, there are several severe challenges ahead, and more so with China 7. Euro 7 also brings important requirements for battery electric vehicles (BEV).

AVL

FEATURES

What to Do, Who Does It, What Tools And Procedures?

Meeting emissions targets is a multi-team effort

THE STAKEHOLDERS

- Legislation authorities
- OEMs, service and repair centers, owners and operators
- Calibration and development teams

THE TARGETS

- Passing type approval, meeting customer expectations, and maintaining in-use emissions compliance

THE MEANS

- Simulation, test and measurement instrumentation, facilities and procedures for propulsion system and vehicle development, validation, and calibration
- Communication and documentation with authorities and OEMs

INSTRUMENTATION AND FACILITY PROVIDERS

- Be it engine-out or tailpipe emissions, fuel or electric energy consumption, on the testbed or on the road – You benefit from expertise and support when installing, upgrading, and operating any type of facility.

FACILITY OPERATORS

- Organize and maintain test quality, handle complex systems, and respond to any test issues – for instruments, analysis, or system handling.

Euro 7

Even a softened Euro 7 legislation has several severe challenges for BEV and ICE vehicles

The Euro 7 main act was approved on April 24, 2024. The technical details must be finalized within 12 months. The important challenges are shown below and changes to the current legislation are highlighted in blue:

	Euro 7	Light-Duty Vehicles	Heavy-Duty Vehicles
	Implementation	Q4 2026: New types / Q4 2027: All vehicles Implementing regulations 29.05.2025	Q2 2028: New types / Q2 2029: All vehicles
Tailpipe UNR-154	Limit	Same as Euro 6 mg/km / #/km	-50 % of EU-VI mg/kWh / #/kWh
	Pollutants	CO, NOx, THC, NOx+THC, NMHC, PM, PN10	CO, NOx, NMOG, CH_4, NH_3 as mass, N_2O, HCHO (HCHO will be reviewed in 2027), PM, PN10
	Fuel	Separate limits for diesel and gasoline	-
RDE UNR-168	Pollutants	CO, NOx, THC, NOx+THC, NMHC, PN10	CO, NOx, NMOG, CH_4, NH_3 as mass, N_2O, HCHO (HCHO will be reviewed in 2027), PN10
	Temperature	0 °C to +35 °C extended -7 °C to +38 °C	-7 °C to +35 °C
	Altitude	700 m extended 1,300 m	~1,700 m, based on abs. pressure
	Driving	Euro 6 limitations	Euro VI limitations, but 6 % power threshold
Non-Tail-pipe	Brake wear	WLTP-B cycle, 7 mg/km and 3 mg/km for PEV	Yes (procedure tbd)
	Tire microplastics	Yes, tire C1 in 2028, tire C2 in 2030 (procedure tbd)	Yes, tire C3 in 2032
	EVAP	1.5 g instead of 2.0 g	No
Others	OBM on-board monitoring	NOx, PM	NOx, NH_3, PM
	Anti-tampering	Yes	Yes
	Durability	Emissions, battery, e-range, state of health	Emissions, battery, e-range, state of health
GHG	**CO_2, energy, and e-range**	**Chassis dyno WLTP**	**Engine testbed data and VECTO simulation**

China 7

China 7 on the way to the world's most challenging emissions testing legislation

The upcoming Chinese legislation China 7 (plans and drafts) describe the most severe emissions testing legislation worldwide. The main challenges are shown below and changes to the current legislation are highlighted in blue:

	China 7	Light-Duty Vehicles	Heavy-Duty Vehicles
Tailpipe	Implementation	• New types and all vehicles 2028/2029 • Implementation Q1/Q2 2026	• New types and all vehicles 2029/2030 • Implementation Q4/2027
	Limit	tbd	tbd
	Pollutants	NOx+NMHC, NH_3, HCHO or NMOG, PN10	NOx, CO, PN10, CH_4, N2O, CO_2
	Fuel	Including M100	-
	Drive cycle	WLTC	WHTC, WHSC, no WNTE, LLC, NOx idle in discussion
	Altitude simulation	Up to 700m (TA), up to 2,400m (COP, ISC) altitude chamber or engine-in and tailpipe pressure	tbd
	Non-normal temperature	-10 °C - 40 °C with A/C and sun simulation	-
RDE Tailpipe Emissions Type II	Pollutants	NH_3, PN10, NMHC, for future N_2O, HCHO, PM	NOx, CO, PN10, CH_4, N_2O, CO_2
	Temperature	0 °C to +35 °C extended -10 °C or -7 °C to +40 °C	-7 °C to +40 °C
	Altitude	700 m extended 2,400 m	Up to 2,400 m
	Driving	Urban, rural, freeway – same as China 6	300 s moving average window, maybe NOx sensor warm-up excluded (still in discussion)
Non-Tailpipe	Brake wear	China 7 draft refers to GTR 24	-
	EVAP	Near-zero emissions hot soak, Bleed Emissions Test Procedure, ORVR	-
GHG	**CO_2, energy, and e-range**	**CO_2, CH_4, N_2O, and energy consumption**	**For different power classes and use cases own Chinese simulation tool (like VECTO in EU)**

USA

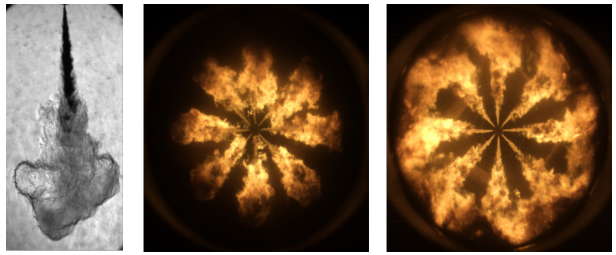
USA legislation will further reduce emission limits especially for PM from light-duty vehicles and NOx from heavy-duty vehicles

USA is gradually changing legislation requirements (phase in). Meaning progress is business as usual. The main upcoming challenges are shown below and changes to the current legislation are highlighted in blue:

	US	Light-Duty	Heavy-Duty
Tailpipe Emissions on Testbed CFR-1066 CFR-1065	Gaseous pollutants	NMOG + NOx reduction • To 30 mg/mi in 2025 • To 12 mg/mi in 2032	Low NOx CARB standard
	PM/PN pollutants	• PM reduction from 3 mg/mi to 0.5 mg/mi to force the use of gasoline particulate filters (GPF)	
	Test cycle and procedures	• Cold-start emissions are not well represented by FTP-75, due to late drive-away. Discussion to adjust FTP • Discussion about shorter soak times, or partial soak from 10 min to 12 h	Duty cycles: Transient cycle (HDT), Supplemental Emissions Test (SET), and Low Load Cycle (LLC)
Greenhouse Gases (GHG)		**• Multi-pollutant legislation to combine pollutant and GHG in a single act. • CO_2 target of 82 g/mi in 2032 (-56 % from 2026 target) will require a significant increase of zero-emission vehicles. • CARB Advanced Clean Car II program to have 100 % ZEV and PHEV sales in 2035. CARB regulations also apply to 14 US states.**	**• Greenhouse gas emissions (Phase 2 and Phase 3) CO_2, CH_4, and N_2O. • Additional fuel mapping cycle, steady state, idle, cruise at 55 and 65 mph, and transient. • For the conventional ICE propulsion system, this is well-known and relatively easy. For vehicle emissions in g/ton-mile, this is based on the "EPA GEM" vehicle simulation tool. • For hybrid propulsion systems this is extremely complex and time-consuming**

Understanding Combustion and Aftertreatment

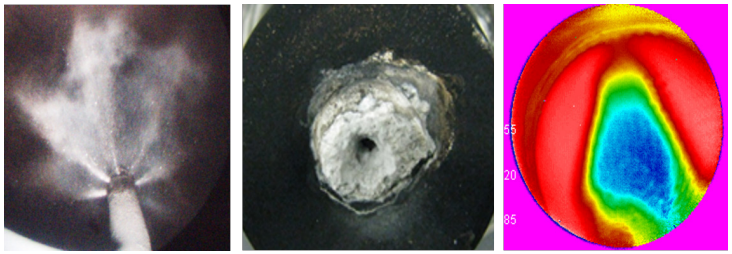
A deep dive into the root causes of emissions

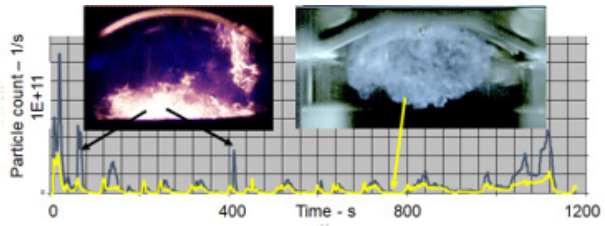


Spray – vapor – flame sequences in a HD diesel engine.

Examples of diesel combustion and aftertreatment issues

Urea sprays, deposit buildup on urea nozzle, non-uniform spray impact on the SCR (selective catalytic reduction) front surface.

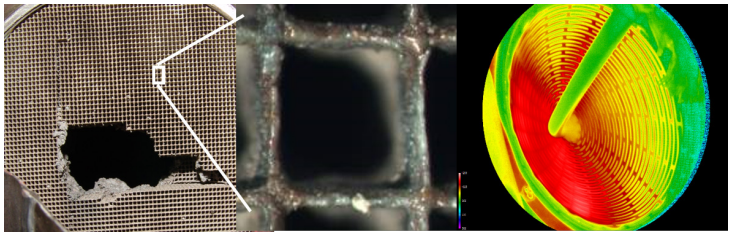




Gasoline combustion with clean, premixed flames (blue) and hot soot particles (white)

Examples of gasoline combustion and aftertreatment events

Catalyst temperature risks: Overheating and breakdown of a 3-way catalyst. Root causes are related to non-uniform exhaust gas flow.



The understanding of elementary combustion and aftertreatment processes is a key part for developing low emission vehicles. AVL offers the corresponding solution portfolio.

Sustainable Fuels and Energy Challenges

Carbon-neutral mobility does not depend on the engine/motor, but on the energy and fuel used!

For internal combustion engines (ICE), the most effective way to reduce CO_2 emission is to use carbon-neutral fuels, like e-fuels or biofuels, and non-carbon fuels, such as hydrogen or ammonia.

CARBON-NEUTRAL, BIO-, OR E-FUELS

E-fuels are tested and measured in the same way as fossil fuels, but biofuels also require ethanol, methanol, and formaldehyde emissions to be measured. This is the field of FTIR technology. The laboratory version is the AVL SESAM i60 FT, and the road version is the AVL M.O.V.E FT.

NON-CARBON FUELS, LIKE HYDROGEN OR AMMONIA

Current regulations and legislation are not fully prepared for such fuels. AVL contributes widely to the development of new regulations. The most complete work is done to ISO 8178 standard, where AVL proposes all measurement-related specifications and all required calculations. AVL measurement systems are prepared for the challenges of high water content in the exhaust and low interferences in analyzers.

E-MOBILITY

Electric mobility is seen as the mainstream technology of the future, be it battery electric or hydrogen-based fuel cell technologies. AVL has the testbeds and measurement systems for R&D, calibration, and type approval.

Emissions: PN10, NH_3, HCHO, Ultra-Low NOx and PM

AVL's 60 years of emissions experience solves your forthcoming test requirements

FROM PN23 TO PN10

In Euro 7 the particulate number must be measured down to 10 nm, previously it was 23 nm. PN 10 nm emissions are approx. 50% higher than PN 23 nm. It must be measured in laboratory tests as well as on the road (RDE). Some non-EU countries will continue to use PN 23 nm.

NH_3, HCHO, NMOG, METHANOL AND ETHANOL

Specific requirements must be fulfilled along the entire sampling stream.
AVL prefers FTIR technology. Depending on the measurement system set-up, solutions for raw exhaust, partial flow dilution, and full flow dilution are available, as well as analyzers for laboratory or in-vehicle RDE testing. The new NH3 PEMS is an easy-to-use device when only NH3 needs to be measured, e.g., for OBM evaluation.

ULTRA-LOW NOX

In 2027, the CARB will reduce the heavy-duty NOx limits by a factor of 10 (0.02 g/bhp-hr). Measurement of such low emission levels is challenging. It requires the super-low NOx CLD analyzer, which can measure 0.1 ppm with ± 0.002 ppm accuracy.

ULTRA-LOW PM

The USA will lower its light-duty PM limit to 0.5 mg/mi to force the implementation of gasoline particulate filters (GPF). The measurement requires a perfect weighing process, which is achieved with the AVL FWR automatic filter conditioning and weighing process.

AVL APC xApp
Advanced Particle Counter

AVL PN Advanced 23/10nm
PEMS Particle Counter

Laboratory FTIR AVL
SESAM i60 FT

PEMS FTIR
AVL M.O.V.E FT

AVL AMA SL

AVL FWR – Filter
Weighing Robot

AVL

FEATURES

Non-Tailpipe Emissions: Brake and Tire Wear and EVAP

Important requirements for all vehicles – conventional as well as electric

NON-TAILPIPE PARTICLES FROM VEHICLES

Since most ICE vehicles have particulate filters, brakes, tires, and the road are the dominant sources of particulates. In Europe alone, tires are responsible for up to 500,000 tons of microplastic emissions per year. Europe, followed by China, will regulate PM and PN emissions from brakes and plastic mass emitted from tires. This is also an important issue for battery electric vehicles.

AVL BRAKE PARTICLE EMISSION SOLUTION

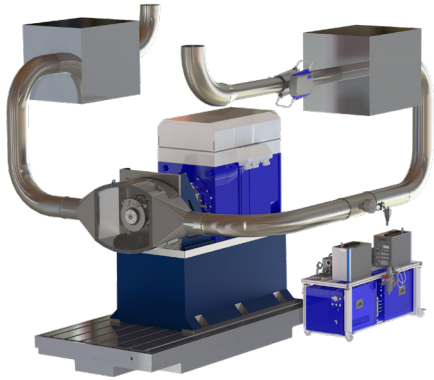
A dynamometer test method for PM2.5, PM10, SPN10 (solid particle number), TPN10 (total particle number) is based on the WLTP brake cycle. Such testing requires robust integration of subsystems such as the brake dynamometer, brake control, cooling air, brake enclosure with sampling tunnel, PM and PN sampling, and data recording. This combination ensures that the requirements of UN GTR-24 are met. All these components are an integral part of AVL's brake wear testbed solution.

MICROPLASTIC EMISSIONS FROM TIRE ABRASION

In 2028, the EU will introduce a limit for tire wear on passenger cars. The measurement method and limit are under development. The current proposal is a convoy test over approx. 2,000 km with 4 identical vehicles. The tires will be weighed before and after the test. Once the procedure is finalized, AVL will define its solution for such a test.

EVAPORATIVE (EVAP) EMISSIONS

EVAP has long been a challenging issue in the USA. Euro 7 will further reduce limits and China 7 will require near-zero emissions. AVL's extensive EVAP portfolio meets all hardware, conditioning, and automation system requirements.



Weight of new tire > Convoy test > Weight of used tire

Conclusion

Forthcoming emissions challenges of Euro 7, China 7, and USA

LEGISLATION

Worldwide legislation - like Euro 7, China 7, USA and others - defines the requirements for new engines and vehicles. What was previously emission legislation only, is now emission, energy, as well as non-tailpipe emission legislation – covering all types of vehicles.

AVL follows and is closely involved in the legislation process, evaluates upcoming challenges, and develops testing and measurement solutions.

MEASURING IS KEY TO MEETING REGULATORY AND TECHNICAL CHALLENGES

Any legislative requirement is only as good as its testing and measurement. “You don’t get what is specified, you get what you inspect.”

Based on customer target markets, types of fuels, energy sources, and types of propulsion system technology, AVL offers solutions tailored to any customer’s requirements.

Abbreviations

CARB	California Air Resources Board
EVAP	evaporative emissions
GHG	greenhouse gases
HD	heavy duty
ICE	internal combustion engine
ISC	in-service compliance
LD	light duty
M100	100% methanol fuel
OBD	on-board diagnostics
OBM	on-board monitoring
OEM	Orignial Equipment Manufacturer
PEMS	portable emissions measurement system
PM	particle mass
PN	particle number
RDE	Real Driving Emissions
SCR	selective catalytic reduction
WLTP	Worldwide Harmonized Light Vehicles Test Procedure
ZEV	zero-emissions vehicle
UN GTR-24	UN standard for Laboratory Measurement of Brake Emissions for Light-Duty Vehicles

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