



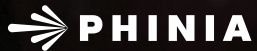
WORLDWIDE EMISSIONS STANDARDS FOR LIGHT-DUTY VEHICLES

- PASSENGER CARS
- LIGHT TRUCKS
- LIGHT COMMERCIAL VEHICLES
- L-CATEGORY

2025/2026



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INTRODUCTION

This booklet is a pocket-sized summary of the ever-changing worldwide emissions standards for light-duty vehicles including passenger cars and other classes. The booklet covers standards on pollutant emissions (oxides of nitrogen, hydrocarbons, carbon monoxide, particulate matter and others) for all engine types for light-duty vehicle categories. Additionally, it covers fuel consumption, greenhouse gas emissions (especially CO₂) and zero-emission vehicle standards for on-road vehicles and engines.

Emissions standards are composed of limit values, standard test cycles, testing conditions and references to the relevant fuel standards.

Complementing the emission standards, the booklet also provides an overview of on-board diagnostics and monitoring of emissions, and standards for reference fuels.

DISCLAIMER

The information provided in this guide on global emissions standards is sourced from publicly available data and reputable sources. While diligent efforts have been made to ensure accuracy, the constantly evolving nature of regulations may result in occasional discrepancies or outdated information. Readers are advised to verify the current regulations and standards with official government agencies, legal counsel and/or other relevant authorities or advisors before making decisions or taking action based on the information presented herein. This guide is intended for informational purposes only and should not be construed as legal or professional advice. The publishers of this guide are not liable for any errors, omissions, or consequences arising from or relating to the use of this information and undertake no obligation to publicly update this guide, whether as a result of new information, future events or otherwise.

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GLOSSARY

ABT	Banking and Trading
ACC	Advanced Clean Car
AECD	Auxiliary Emission Control Device
AER	All Electric Range
AES	Auxiliary Emission Strategy
ATCT	Ambient Temperature Correction Test
BAB	BundesAutoBahn
BES	Base Emission Strategy
BEV	Battery Electric Vehicles
BS	Bharat Stage
BV	Bed Volume
CAFC	Corporate Average Fuel Consumption
CAFE	Corporate Average Fuel Economy (US)
CF	Conformity Factor
CI	Compression Ignition
CM	Curb Mass
CN	China
CNG	Compressed Natural Gas

COP	Conformity of Production
DF	Deterioration Factor
DI	Direct Injection
DOC	Diesel Oxidation Catalyst
DPF	Diesel Particle Filter
EEC	Electric Energy Consumption
EEEDWS	Exceed Exhaust Emissions Driver Warning System
EGR	Exhaust Gas Recirculation
EI-AECD	Emission Increase AECD
EOBD	European Union On-board Diagnostic
EUDC	Extra Urban Driving Cycle
EVAP	Evaporative Emissions
FAME	Fatty Acid Methyl Esters
FC	Fuel Consumption
FCEV	Fuel Cell Electric Vehicle
FCV	Fuel Cell Vehicle
FCVH	Fuel Cell Vehicle – Hydrogen
FE	Fuel Economy

FIE	Fuel Injection Equipment
FTP	Federal Test Procedure
GDI	Gasoline Direct Injection
GHG	Greenhouse Gas
GTR	Global Technical Regulation
GVW	Gross Vehicle Weight
GVWR	Gross Vehicle Weight Rating
H₂ICE	Hydrogen Internal Combustion Engine
HDV	Heavy-Duty Vehicle
HEV	Hybrid Electric Vehicle (w/o plug)
HLDT	Heavy Light-Duty Truck
HWFET	Highway Fuel Economy Test
ICE	Internal Combustion Engine
ICEV	Internal Combustion Engine Vehicle
ISC	In-Service Conformity
ISV	In-Service Verification
IUPR	In-Use Performance Ratio
IUPRM	Monitoring of IUPR

GLOSSARY

LBS	Pounds (1 lb = 454 g)
LCV	Light Commercial Vehicle
LDT	Light-Duty Trucks
LEV	Low Emission Vehicle
LLDT	Light Light-Duty Trucks
LPG	Liquefied Petroleum Gas
LVW	Loaded Vehicle Weight
MaS	Market Surveillance
MDPV	Medium-Duty Passenger Vehicle
MIDC	Modified Indian Driving Cycle
MIL	Malfunction Indication Lamp
MTBE	Methyl Tertiary Butyl Ether
MVEG	Motor Vehicle Emissions Group
MY	Model Year
NEDC	New European Driving Cycle
NEV	New Energy Vehicle (China)
NEV	New Electric Vehicle

NIRCO	Non-Integrated Refueling Canister Only
NMHC	Non-Methane Hydrocarbons
NMOG	Non-Methane Organic Gases
NOVC	Normally Open Vapor Canister
NOVC-HEV	Non-Off-Vehicle Charging Hybrid Electric Vehicle
NT	New Types
NTE	Not To Exceed
NV	All New Vehicles
NYCC	New York City Cycle
OBD	On-board Diagnostic
OBDBr	OBD in Brazil
OBFCM	On-Board Fuel Consumption Monitoring
OBM	On-Board Monitoring
OEM	Original Equipment Manufacturer
ORVO	Open Refueling Vapor Outlet
ORVR	On-board Refueling Vapor Recovery
OVC	Off-Vehicle Charging

OVC-HEV	Off-Vehicle Charging Hybrid Electric Vehicle
PC	Passenger Car
PEMS	Portable Emission Measurement System
PEV	Pure Electric Vehicle
PF	Permeability Factor
PHEV	Plug-in Hybrid Electric Vehicle
PI	Positive Ignition
PM/PN	Particulate Mass/Number
PMR	Power to Mass Ratio
PZEV	Partial Zero Emissions Vehicle
RDE	Real Driving Emissions
REESS	Rechargeable Energy Storage Systems
RM	Reference Mass
RPA	Relative Positive Acceleration
RVP	Reid Vapor Pressure
SAFE	Safer Affordable Fuel-Efficient Vehicles Rule

GLOSSARY

SFTP	Supplemental Federal Test Procedure
SHED	Sealed Housing Emissions Device
SI	Spark Ignition
SRC	Standard Road Cycle
SULEV	Super Ultra Low Emissions Vehicle
TA	Type Approval
TFL	Transport For London
THC	Total Hydrocarbons
TM	Test Mass
TZEV	Transitional ZEV = PHEV
UDDS	Urban Dynamometer Driving Schedule
UF	Utility Factor
ULEV	Ultra Low Emission Vehicle
VETS	Vehicle Emissions Trading Scheme
VGT	Variable Geometry Turbocharger

VL	Vehicle Low
VM	Vehicle Makers
VT SHED	Variable Temperature SHED
VVT	Variable Valve Train
WC	Working Cycle
WG	Waste Gate
WLTC	Worldwide Light-duty Test Cycle
WLTP	Worldwide Light-duty Test Procedure
WMTC	World Motorcycle Test Cycle
ZLEV	Zero and Low Emission Vehicle (EU)

Administrations and associations

ABNT NBR	Associação Brasileira de Normas Técnicas - Norma Brasileira
ACEA	European Automobile Manufacturer Association
BEE	Bureau of Energy Efficiency (India)

CARB	California Air Resources Board
ECE	Economic Commission for Europe
EPA	US Environmental Protection Agency
EU	European Union
MVEG	Motor Vehicle Emissions Group, Advisory
JRC	Joint Research Centre
UNECE	United Nations Economic Commission for Europe
AISC	Automotive Industry Standard Committee
SCOE	Standing Committee on Emissions
NCR	National Capital Region
EISA	Energy Independence and Security Act
NHTSA	National Highway Traffic Safety Administration
IBAMA	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis
CONAMA	Conselho Nacional do Meio Ambiente



EXHAUST POLLUTANT EMISSIONS STANDARDS

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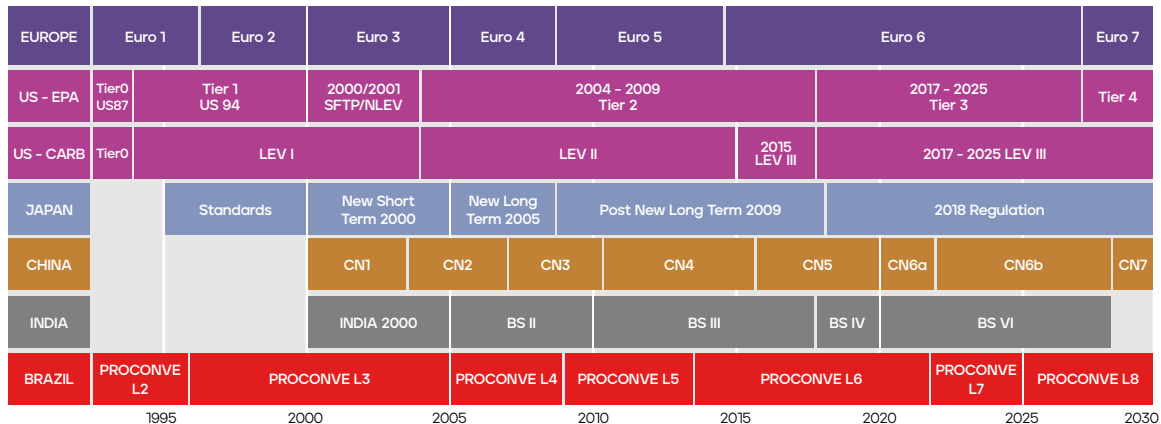
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TIMELINE – TOXIC EMISSIONS STANDARDS PASSENGER CARS



Dates show earliest type approval introduction only. More detail can be found in the booklet.

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EUROPEAN UNION - OVERVIEW

Vehicle categories

Vehicle categories were defined in 1970 by Directive 70/156/EC, as amended by Directive 2007/46/EC. It was repealed and replaced by (EU) 2018 / 858 (Article 4) with no changes.

Category	Description	Subcategory	Number of persons	Mass limit	
M	Carriage of passengers, min. 4 wheels	M₁^a	Up to 9	GVW ≤ 3,500 kg^b	
		M ₂ ^c	> 9	GVW ≤ 5,000 kg	
		M ₃ ^d		GVW > 5,000 kg	
N	Carriage of goods, min. 4 wheels, LCV & HDV	N₁ Class 1^e	N/A	GVW ≤ 3,500 kg	RM ≤ 1,305 kg
		N₁ Class 2^e			1,305 kg < RM ≤ 1,760 kg
		N₁ Class 3^e			1,760 kg < RM ≤ 3,500 kg
		N ₂ ^c		3,500 kg < GVW ≤ 12,000 kg	
		N ₃ ^d		GVW > 12,000 kg	

Bold text denotes categories normally subject to LDV regulation.

^a Passenger car (PC): under certain conditions and regulations, could be subject to the HDV standard.

^b Until Euro 4: Two subgroups: M₁ with GVW ≤ 2,500 kg and M₁ with 2,500 kg < GVW ≤ 3,500 kg.

^c Normally subject to HDV standard, but at the request of the manufacturers and under specific conditions (depending on Regulation), could be subject to LDV standard.

^d Subject only to HDV standard.

^e Light commercial vehicle (LCV): defined in (EU) 715 / 2007 (Annex I). "Class" also denoted as "CL" in the following pages.

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EUROPEAN UNION - OVERVIEW

Type approval emissions testing

In the current EU Regulation, up to 7 types of Emissions tests could be required for a complete Emission Type approval process. The objective is to cover all the conditions where emissions (tailpipe and non-tailpipe) could appear. Often, when speaking about emissions regulations, type 1 and 1A are the reference.

Test	Description	Scope	Requirement	Chapter / Page
Type 1	Tailpipe emissions	All	Measurement of Tailpipe Emissions / CO ₂ on dyno' testing over the WLTP cycle, including ATCT procedure	From page 17, 23 & 34
Type 1A	Real Driving Emissions	All	Measurement of on-road emissions using PEMS	From page 24 to page 30
Type 2	CO emissions at engine idling speeds	PI	Determination of reference value for inspection / maintenance and COP	Not covered here
Type 3	Crankcase gases emissions	PI	Verify the good behavior of the ventilation system to avoid any unburned gases into the atmosphere	Not covered here
Type 4	Evaporative Emissions	PI	Limit the fuel vapor emitted during parking conditions	Page 169 & 171
Type 5	Durability of pollution control devices	All	Check of the durability of pollution control devices / determination of Deterioration Factor (DF)	Page 20 & 21
Type 6	Low Temperature emissions	PI / (CI)	Verify the emissions at cold conditions (-7°C)	Page 22

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	Vehicle class		Introduction date NT	Legislative reference	Test cycle	Emissions limits (g/km) laboratory cycle PI / CI						Durability (km)						
						CO	NMHC	HC	HC + NOx	NOx	PM		PN x 10 ⁿ -/ km					
Euro 1	M ₁ with GVW ≤ 2,500 kg		Jan 1992	91/441/EEC or 93/59/EEC	Urban (40 sec. idle) + EUDC	2.72 (3.16) ^a	-	-	0.97 (1.13) ^a	-	- / 0.14 (0.18) ^a	-	80,000 or 5 years					
	M ₁ with GVW > 2,500 kg & N ₁ CL 1 ^b		Oct 1993	93/59/EEC		5.17 (6) ^a			1.4 (1.6) ^a		- / 0.19 (0.22) ^a							
	N ₁	CL 2 ^b				6.9 (8) ^a			1.7 (2) ^a		- / 0.25 (0.29) ^a							
		CL 3 ^b																
Euro 2	M ₁ with GVW ≤ 2,500 kg		Jan 1996	94/12/EC or 96/69/EC	NEDC (Revised Urban + EUDC)	2.2 / 1.0	-	-	0.5 / 0.7	-	- / 0.08	-	80,000 or 5 years					
	M ₁ with GVW > 2,500 kg & N ₁ CL 1 ^b		Oct 1996	94/12/EC or 96/69/EC, 93/116/EC	Urban (40 sec. idle) + EUDC													
	N ₁	CL 2 ^b	Oct 1997		4 / 1.25	0.6 / 1.0 (1.3) ^a			- / 0.12 (1.4) ^a									
		CL 3 ^b	Oct 1998		5 / 1.5	0.7 / 1.2 (1.6) ^a			/ 0.17 (0.20) ^a									

^a Conformity of production (COP) values in brackets.

^b Vehicle classes: Class 1: GVW ≤ 1250 kg, Class 2: 1250 kg < GVW ≤ 1700 kg, Class 3: GVW > 1700 kg.

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	Vehicle class		Introduction date NT	Legislative reference	Test cycle	Emissions limits (g/km) laboratory cycle PI / CI						Durability (km)	
						CO	NMHC	HC	HC + NOx	NOx	PM		PN x 10 ¹¹ - / km
Euro 3	M ₁ ^d & N ₁ CL 1		Jan 2000	70/220/EC, Amended by 98/69/EC & 2002/80/EC	NEDC (Revised Urban + EUDC)	2.30 / 0.64	-	0.20 / -	- / 0.56	0.15 / 0.50	- / 0.05	-	80,000 or 5 years
	N ₁ ^e	CL 2	Jan 2001			4.17 / 0.80		0.25 / -	- / 0.72	0.18 / 0.65	- / 0.07		
		CL 3				5.22 / 0.95		0.29 / -	- / 0.86	0.21 / 0.78	- / 0.10		
Euro 4	M ₁ ^d & N ₁ CL 1		Jan 2005	70/220/EC, Amended by 98/69/EC & 2003/76/EC	NEDC (Revised Urban + EUDC)	1.00 / 0.50	-	0.10 / -	- / 0.30	0.08 / 0.25	- / 0.025	-	100,000 or 5 years ^c
	N ₁ ^e	CL 2	Jan 2006			1.81 / 0.63		0.13 / -	- / 0.39	0.10 / 0.33	- / 0.040		
		CL 3				2.27 / 0.74		0.16 / -	- / 0.46	0.11 / 0.39	- / 0.060		

^c Required recording of in-use durability.

^d Excluding passenger cars with GVW > 2,500 kg.

^e Plus passenger cars with GVW > 2,500 kg.

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	Vehicle class	Introduction date NT	Legislative reference	Test cycle	Emissions limits (g/km) laboratory cycle PI / CI							Durability (km)
					CO	NMHC	HC	HC + NOx	NOx	PM	PN x 10 ¹¹ - / km	
Euro 5	M ₁ & N ₁ CL 1	Sep 2009	(EC) 715/2007, amended by (EC) 692/2008 (EU) 2017/1151	NEDC	1.00 / 0.50	0.068 / -	0.10 / -	- / 0.230	0.060 / 0.180	0.0045 ^{e,h}	- / 6 ⁱ	100,000 or 5 years
	N ₁ CL 2	Sep 2010			1.81 / 0.63	0.090 / -	0.13 / -	- / 0.295	0.075 / 0.235			
	N ₁ CL 3				2.27 / 0.74	0.108 / -	0.16 / -	- / 0.350	0.082 / 0.280			
Euro 6 ^g	M ₁ & N ₁ CL 1	From Sep 2014	(EC) 715/2007, amended by (EC) 692/2008 (EU) 2017/1151 amended by (EU) 2018/1832	NEDC for Euro 6b WLTC starting Euro 6c	1.00 / 0.50	0.068 / -	0.10 / -	- / 0.170	0.060 / 0.080	0.0045 ^e	6 ^{e,f}	100,000 ^j or 5 years
	N ₁ CL 2	From Sep 2015			1.81 / 0.63	0.090 / -	0.13 / -	- / 0.295	0.075 / 0.105			
	N ₁ CL 3				2.27 / 0.74	0.108 / -	0.16 / -	- / 0.350	0.082 / 0.125			

^e Applicable to PI Direct Injection engines only.

^f Until 3 years after the dates for TA/FR particle emission limit of 6×10^{12} may be applied for Euro 6b positive ignition DI vehicles upon request of manufacturer.

^g Euro 6 steps detailed are given in the Euro 6 section.

^h This value applies only starting Jan 2012 with Euro 5b application - From Jan 2010 to Jan 2012, PM = 0.005 (Euro 5a).

ⁱ This value is applicable only starting Jan 2012 with Euro 5b application.

^j Market Surveillance tests could be made over 160,000 km.

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	Vehicle class	Introduction date NT	Legislative reference	Test cycle	Emissions limits (g/km) laboratory cycle PI / CI							Durability (km)
					CO	NMHC	HC	HC + NOx	NOx	PM	PN x 10 ¹¹ - / km	
Euro 7 (limits identical to Euro 6)	M ₁ & N ₁ CL 1	Nov 2026	(EU) 2024/1257	WLTC	1.00 / 0.50	0.068 / -	0.10 / -	- / 0.170	0.060 / 0.080	0.0045	6	200,000 or 10 years ^k
	N ₁ CL 2				1.81 / 0.63	0.090 / -	0.13 / -	- / 0.295	0.075 / 0.105			
	N ₁ CL 3				2.27 / 0.74	0.108 / -	0.16 / -	- / 0.350	0.082 / 0.125			

^k Main Lifetime up to 160,000 km or 8 years - beyond that, a durability multiplier (1.2) is used for gaseous pollutants.

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EUROPEAN UNION - EURO 6

Euro 6 was implemented in several steps:

	Description	Vehicle class			
		M, N ₁ CL 1		N ₁ CL2, 3 N ₂	
		NT ^a	NV ^b	NT ^a	NV ^b
Euro 6b	MVEG process with new limits + OBD Euro 6-1	Sep 2014	Sep 2015	Sep 2015	Sep 2016
Euro 6c	Euro 6b + WLTP (cycle & procedure) + final PN standard for PI vehicles + OBD Euro 6-2 + use of E10 and B7 reference fuel, assessed on regulatory lab test cycle + RDE PN (NTE emission limits applied) + RDE NOx testing for monitoring only	Sep 2017	Sep 2018	Sep 2018	Sep 2019
Euro 6d-TEMP	Euro 6c + RDE testing against temporary Conformity Factors	Sep 2017	Sep 2019	Sep 2018	Sep 2019
Euro 6d-TEMP-ISC	Euro 6d-TEMP + new ISC procedure (incl. RDE, type 4, type 6 tests)	Jan 2019			
Euro 6d-TEMP-EVAP-ISC	Euro 6d-TEMP-ISC + 48h evaporative test procedure	Sep 2019	Sep 2019	Sep 2019	Sep 2020
Euro 6d-ISC-FCM	Euro 6d-TEMP-EVAP-ISC + onboard fuel and/or electric energy consumption monitoring device + RDE testing against Final Conformity Factors	Jan 2020	Jan 2021	Jan 2021	Jan 2022
Euro 6e	Euro 6d-ISC-FCM + RDE compliance considering updated PEMS margins, OBFCEM for N ₂ vehicles	Sep 2023	Sep 2024	Sep 2023	Sep 2024
Euro 6e-bis	Euro 6e + increased extended ambient conditions for RDE compliance + AES Flag + updated utility factor (equivalent to UNR168)	Jan 2025	Jan 2026	Jan 2025	Jan 2026

^a NT = new types (newly introduced vehicle models).

^b NV = all vehicles, also known as AT (all types = all new vehicles).

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EUROPEAN UNION - EURO 6

Vehicle scope (Euro 5 & 6)

M₁ and M₂, N₁ and N₂ vehicles as defined in Directive 70/156/EC with reference mass $\leq 2,610$ kg.

Extension possible at the manufacturer's request to M₁, M₂, N₁ and N₂ with reference mass $\leq 2,840$ kg.

Test cycles

NEDC was used in the first phase of Euro 6 (Euro 6b), and then replaced by WLTC.

The Real Driving Emission (RDE) test procedure was introduced in 3 phases.

- First a monitoring period starting in April 2016 on new type vehicles
- Followed by a period with application of temporary conformity factors (Euro 6d-TEMP)
- Then with application of final conformity factors (Euro 6d)

See EUROPEAN UNION - REAL DRIVING EMISSIONS section for more details on the RDE test procedure.

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EUROPEAN UNION - EURO 6

Conformity of Production (COP)

The conformity of production procedure aims to ensure that each vehicle, system, component and technical separate unit, part or equipment produced is in conformity with the approved type.

Emission tests are made at the end of the vehicle production (~0 km) to check the Conformity of Production: Type 1 (only WLTC) and on-board fuel consumption monitoring (OBFM) accuracy check.

A statistical approach is generally made.

In-Service Conformity (ISC) - Euro 5 & 6

Testing is performed at min. 6 months and 15,000 km, max. 100,000 km or 5 years whichever is sooner.

ISC is applied on Type 1 WLTP and RDE, Type 4 and Type 6 tests.

ISC is open to testing by National Type Approval Authorities and Third Parties.

A statistical approach is generally made.

Market Surveillance (MaS)

MaS (Market Surveillance) was introduced in 2020 after the so-called 'Dieselgate' scandal.

The objective is to check emissions compliance within and outside the regulated conditions. All certification values can be tested during MaS.

Tests are conducted either by European Commission's Joint Research Centre (JRC) or by National Type Approval Authorities and can be made on non-regulated cycles such as BAB130 (German highway), TFL (London Urban Inter Peak) or Artemis (based on a European research project).

Vehicles are selected according to the risk assessment principles: severity and likelihood of non-compliance; new technology; past history; results of remote sensing testing; concerns reported by recognized third parties.

A yearly report is available on JRC website.



EUROPEAN UNION - EURO 6

Defeat devices, AES / BES documentation and flags

Defeat devices that reduce the effectiveness of emission control systems shall be prohibited with some exceptions mainly linked to safety, engine start or if the conditions are substantially included in the test procedures.

This prohibition needs to be considered together with the rules laid down in Commission Regulation (EU) 2017/1151 regarding Auxiliary Emission Strategies (see below).

Starting with Euro 6d-temp, the manufacturer shall provide an extended documentation package where emissions strategies are described:

- Base Emissions Strategies (BES) - the emission strategy active throughout the standard speed and load operating range of the vehicle unless an auxiliary emission strategy is activated
- Auxiliary emission strategy (AES) - an emission strategy that becomes active and replaces or modifies a BES in response to a specific set of ambient or operating conditions and only remains operational as long as those conditions exist

For each AES, a clear justification of the use and an explanation of its impact on pollutants and CO₂ need to be given.

Starting with Euro 6e-bis, the manufacturer shall introduce an indicator (AES Flag or Timer) to indicate when a vehicle runs in AES mode. The indicator shall be available via the serial port of a standard diagnostic connector upon request of a generic scan-tool. The AES that is running shall be identifiable via the documentation package.

A list of AES which were deemed non-acceptable by type approval authorities shall be compiled yearly.



EUROPEAN UNION - EURO 6

Durability requirements starting with Euro 6c (Type 5 test)

Deterioration factors are used to determine emissions of an aged system compared to new. They are used during Type-Approval and COP testing.

Starting Euro 6c^a, they can be determined only by one of the following methods described in the Annex C4 of the UNR154:

- A whole vehicle ageing test covering its useful life (test track, on the road or on chassis dyno), using the Standard Road Cycle (SRC)
- Where applicable a manufacturer may choose to apply the assigned deterioration factor (multiplicative or additive), but these must later be verified on an aged system

^a On previous regulations (Euro 5 & Euro 6b), the durability requirements followed UNR 83 process. There, an additional method could be used, called Bench ageing (or rapid ageing) durability test. A cycle (specific for CI & PI) is repeated on engine bench in order to simulate exhaust line ageing.

Assigned multiplicative deterioration factors (Euro 5 / Euro 6)

Engine category	CO	THC	NMHC	NO _x	HC + NO _x	PM	PN
Positive Ignition	1.5	1.3	1.3	1.6	-	1.0	1.0
Compression Ignition	As there are no assigned deterioration factors for compression ignition vehicles, manufacturers shall use the whole vehicle or bench ageing durability test procedures to establish deterioration factors						



EUROPEAN UNION - EURO 6

Assigned additive deterioration factors (starting Euro 6c)

Category	Technically permissible maximum laden Mass (GVW) (kg)	Mass of carbon monoxide (CO)		Mass of non-methane hydrocarbons (NMHC)		Mass of oxides of nitrogen (NOx)			Mass of particulate matter (PM)		Particle Number (PN)	
		L ₁ (mg/km)		L ₂ (mg/km)		L ₄ (mg/km)			L ₅ (mg/km)		L ₆ (#/km)	
Category		G	D / O	G	D / O	G	D	O	G ^a	D / O	G ^a	D / O
M	All	127		12		11			0		0	
N ₁	GVW ≤ 1,700 ^b	127	— ^d	12	— ^d	11	— ^d	— ^d	0	— ^d	0	— ^d
	1,700 < GVW ≤ 3,500	281		18		15			0		0	
	All ^c	327	—	9	—	8	—		0	—	0	—

G Petrol, LPG.

D Diesel.

O Other fuel.

^a For petrol or LPG, particulate mass (PM) and particle number (PN) limits shall apply only to vehicles with direct injection engines.

^b Except vehicles having engine displacement less than or equal to 0.660 liter, vehicle length less than or equal to 3.40 m, vehicle width less than or equal to 1.48 m, and vehicle height less than or equal to 2.00m, seats less than or equal to 3 in addition to a driver, and payload less than or equal to 350 kg.

^c Vehicles having engine displacement less or equal to 0.660 liter, vehicle length less than or equal to 3.40 m, vehicle width less than or equal to 1.48 m, and vehicle height less than or equal to 2.00m, seats less than or equal to 3 in addition to a driver, and payload less than or equal to 350 kg.

^d As there are no assigned deterioration factors for compression ignition vehicles, manufacturers shall use the whole vehicle ageing durability test procedures to establish deterioration factors.

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Low Temperature Test (-7°C) (Type 6 test)

The Type 6 test is an additional requirement at cold conditions.

The general requirements for the Type 6 test are mainly those set out in section 5.3.5 of UN/ECE Regulation No. 83 with specific limits. Reference cycle is NEDC.

Starting with Euro 6e, this test shall be carried out on all vehicles except those having compression-ignition engines. For previous steps (Euro 6b -> Euro 6d), for CI vehicles, manufacturers shall present information - showing that the NO_x aftertreatment devices reach a sufficiently high temperature for efficient operation within 400 sec. after a cold start - on the operating strategy of the EGR system including functioning at low temperatures.

Emission limit of PI vehicles for the CO and THC emissions after cold start:

Vehicle category	CO limit (g/km)	THC limit (g/km)
M, N ₁ , CL 1	15	1.8
N ₁ , CL 2	24	2.7
N ₁ CL 3, N ₂	30	3.2

- The test consists of driving four elementary urban cycles, which together make a complete NEDC Part One cycle
- The low ambient temperature test lasting a total of 780 sec. shall be carried out without interruption and start at engine cranking
- The road load coefficients used shall be those for the vehicle with the lowest CO₂ emissions in the family, known as vehicle low (VL)
- The dynamometer shall be adjusted to simulate the operation of a vehicle on the road at -7 °C, with a road load force adaptation
- Before the test is carried out, the test vehicles shall be pre-conditioned in a uniform manner driving a complete NEDC cycle



EUROPEAN UNION - EURO 6

ECE - WLTP / WLTC

The WLTC cycles are part of the Worldwide harmonized Light vehicles Test Procedures (initially GTR15, transposed in UNR154).

- Introduced in Europe in Sep 2017 for NT and Sep 2018 for NV
- More representative of the real life consumption and emission. It was created using real driving data provided by ECE contracting parties, e.g. EU, Japan, India
- The complete procedure was updated to give:
 - More realistic road load and adaptation
 - A suitable procedure for PHEV / PEV / HEV
 - Gear shift adapted to the vehicle characteristics
 - Updates to the PN measurement methodology
- Vehicles are categorised according to their Power Mass Ratio (PMR) and the cycle is adapted. Furthermore if the vehicle is not able to achieve the speed and acceleration profile of the cycle assigned to its class, the cycle can be modified by downgrading the dynamics to allow the test to be completed (downscaling)

PMR category		PMR (W/kg)	Speed phases (see annex)
Class 3	3a ($V_{\max} < 120$ km/h)	PMR > 34	Low ₃ + Medium _{3a} + High _{3a} + Extra High ₃
	3b ($V_{\max} \geq 120$ km/h)		Low ₃ + Medium _{3b} + High _{3b} + Extra High ₃
Class 2	-	$22 < \text{PMR} \leq 34$	Low ₂ + Medium ₂ + High ₂ + Extra High ₂
Class 1	-	PMR ≤ 22	Low ₁ + Medium ₁ + Low ₁



EUROPEAN UNION - REAL DRIVING EMISSIONS TESTING

Real Driving Emissions (RDE)

RDE is an additional vehicle test performed at type approval, in-service conformity and market surveillance, which is conducted with market fuels. NO_x, PN, CO & CO₂ emissions are measured on public roads in real-life conditions using portable emissions measuring systems (PEMS). CO₂ is not regulated but used as reference value for the post-processing.

The current RDE test procedure is described in Annex IIIA of regulation (EU) 2017/1151 amended by (EU) 2018/1832 and applicable since 1 January 2019 (equivalent to UNR168).

Not to Exceed emissions values for RDE testing

The emissions produced during the RDE trip are recorded every second. When a measurement is taken under extended driving conditions, a correction factor is applied to the emissions results (see next page). The results of the RDE emissions for the entire RDE trip and the urban part alone must remain below the 'Not to Exceed' (NTE) emissions limits as defined by the following equation:

$$NTE_{\text{pollutant}} = CF_{\text{pollutant}} \times \text{EURO-6 limit}$$

$CF_{\text{pollutant}}$ = conformity factor for each pollutant, as presented in the table on the right.

Following a policy change (emission limits can only be changed through co-decision), from Euro 6d onwards, RDE test compliance is calculated as follows:

Final RDE Emission test results / (1 + PEMS margin) ≤ Euro 6e thresholds (see calculation page 30 - Final RDE Emissions test results is including K_i factors).

Conformity Factors (CFs) for Euro 6 RDE

$CF_{\text{pollutant}}$	NO _x	PN	CO ^a
Temporary (Euro 6d-Temp)	2.10	1 + margin PN = 1.50	-
Final (Euro 6d)	1 + margin NO _x = 1.43	1 + margin PN = 1.50	-
Euro 6e	1 + margin NO _x = 1.10	1 + margin PN = 1.34	-

^a CO emissions shall be measured and recorded at RDE tests.

- "Margin" is a parameter taking into account additional measurement uncertainties of PEMS equipment, and is subject to annual review
- RDE in-service conformity testing is performed at maximum 100,000 km vehicle life

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EUROPEAN UNION - REAL DRIVING EMISSIONS TESTING

Boundary conditions of a valid RDE trip

The ambient conditions are 'extended' when the temperature or altitude conditions are in the extended range. If during a particular time interval the ambient conditions are in the extended range, the emission values during this particular time interval are divided by the 1.6 correction factor before being evaluated.

Boundary condition values

Ambient condition	Moderate	Extended
Emissions correction factor	1	1 / 1.6
Temperature	$0 \leq T \leq 35^{\circ}\text{C}$	$-7 \leq T < 0^{\circ}\text{C}; 35 < T \leq 38^{\circ}\text{C}$
Altitude	$\leq 700\text{m}$	$700 < \text{Alt} \leq 1,300\text{m}$

Trip requirement for a valid RDE test

The RDE trip is designed based on street maps. Air conditioning and other auxiliary devices shall be operated in their typical manner. After the test is completed, the following trip verifications are carried out.

- Ambient boundary conditions shall be respected (see above)
- Trip requirements in term of distance proportions, speeds, altitudes as defined in the table on the next page shall be met
- Driving dynamics criteria are also taken into account. These are explained in the following pages



EUROPEAN UNION - REAL DRIVING EMISSIONS TESTING

Trip requirements for a valid RDE test

Driving portion	Urban ^a	Rural	Motorway
	Speed ≤ 60 km/h	$60 < \text{Speed} \leq 90$ km/h ^b	$90 \text{ km/h}^b < \text{Speed}$
Minimum distance	16 km	16 km	16 km
Distance share	29-44%	23-43%	23-43%
Total trip duration	90-120 minutes		
Average speed including stops	$15 < \text{Avg.} < 40$ km/h	-	-
Total stop time ($v < 1$ km/h)	6 - 30% Urban time	-	-
Individual stop time	≤ 300 sec.	-	-
$v > 100$ km/h ^{b,c}	-	-	> 5 min.
$v > 145$ km/h	-	-	$< 3\%$ Motorway time
Cumulative positive elevation gain	$< 1,200$ m / 100 km		
Start/end test elevation difference	≤ 100 m		

- ^a Average speed between 15 and 40 km/h including stops and cold start, total stop time 6-30%, individual stop time less than 300s.
- ^b 80 km/h for N₂ vehicle with 90 km/h speed limiting device.
- ^c 90 km/h for M₂ vehicle with speed limiting device at 100 km/h.

Furthermore, the test can be done with different mass, but not exceeding 90% of the vehicle's permissible payload.

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EUROPEAN UNION - REAL DRIVING EMISSIONS TESTING

Driving dynamics criteria

- Overall driving dynamics shall be within limits defined in table on the right, to insure against:
 - Excessive driving dynamics using the $v.a_{pos}$ (velocity multiplied by positive acceleration) distribution over each portion of the trip (urban, rural and motorway as defined by the trip requirements)
 - Insufficient driving dynamics using the RPA (Relative Positive Acceleration) computed over each portion of the trip (urban, rural and motorway)

Trip dynamics requirements ^a		
No excess	$v \leq 74.6$ km/h	$v > 74.6$ km/h
95 th percentile ($v.a_{pos}$)	max. ($v.a_{pos}$) = $0.136 \times v + 14.44$	max. ($v.a_{pos}$) = $0.0742 \times v + 18.966$ max. ($v.a_{pos}$) ^b = $-0.097 \times v + 31.635$
Sufficiency	$v \leq 94.05$ km/h	$v > 94.05$ km/h
Relative Positive Acceleration	min. (RPA) = $-0.0016 \times v + 0.1755$	min. (RPA) = 0.025

^a v in the formulas are in km/h, $v.a_{pos}$ in m^2/s^3 or W/kg , RPA in m/s^2 or $kWs/(kg.km)$.

^b Upon the choice of the manufacturer for N_1 and N_2 vehicles with a power to mass ratio ≤ 44 W/kg .



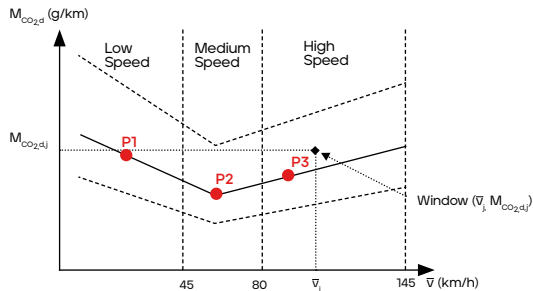
EUROPEAN UNION - REAL DRIVING EMISSIONS TESTING

Vehicle CO₂ characteristic curve

- The objective is to assess the validity of the trip when comparing the CO₂, expressed in g/km, as a proxy for engine load, measured in 'moving average windows' (see right) to the reference CO₂ measured on Type 1 test
- The first step consists of creating the CO₂ characteristic using type 1 test results

Vehicle CO₂ characteristic curve

WLTC phases	Low-speed (LS)	High-speed (HS)	Extra-high speed (EHS)
Reference point	P1	P2	P3
Reference point: Speed (km/h)	18.882 km/h	56.664 km/h	91.997 km/h
Reference point: CO ₂ (g/km)	Mass CO ₂ LS-WLTP	Mass CO ₂ HS-WLTP	Mass CO ₂ EHS-WLTP



- Then, using PEMS 1 Hz data, moving average windows method is used to define windows with CO₂ equal to 1/2 CO₂ mass generated during the entire WLTC
- In each window, vehicle speeds and CO₂ emissions (expressed in g/km) are averaged, and plotted as a point together with the vehicle CO₂ characteristic curve obtained from the WLTP test



EUROPEAN UNION - REAL DRIVING EMISSIONS TESTING

Verification of overall trip dynamics

For verification of overall trip dynamics, the trip is divided into urban, rural and motorway parts based on speed as defined in following table.

The number of windows in each driving part is used to compute the percentage of windows within the tolerances defined for the CO₂ characteristic curve. The test is valid if at least 50% of the windows in each part are within the tolerance band.

	Urban	Rural	Motorway
Windows bins thresholds	Speed < 45 km/h	$45 \leq \text{Speed} < 80$ km/h ^a	$80^a \leq \text{Speed} < 145$ km/h
Tolerances around CO ₂ characteristic curve			
Upper tolerance	+ 45% ^b	+ 40% ^b	+ 40% ^b
Lower tolerance	- 25% for ICE and NOVC-HEV; - 100% for OVC-HEV		
% of windows within the tolerance band			
RDE test valid if	≥ 50%	≥ 50%	≥ 50%

^a 70 km/h for N₂ vehicle with 90 km/h speed limiting device.

^b For NOVC-HEV and OVC-HEV the upper tolerance may be increased by steps of 1% until 50%.



EUROPEAN UNION - REAL DRIVING EMISSIONS TESTING

Final RDE data evaluation

Both the urban and total trip emissions of the RDE must pass the NTE emissions limits after correction with the K_i factors or offsets:

$$M_{\text{pollutant,RDE},k} \text{ (mg/km)} \times K_i \text{ or } + K_i < \text{NTE}_{\text{pollutant}}$$

The RDE results are calculated by multiplying raw emissions by an RDE evaluation factor RF_k for both the urban and the total portions of the RDE trip as defined by the trip requirements (k = urban; k = total respectively).

$$M_{\text{pollutant,RDE},k} \text{ (mg/km)} = \frac{\text{Pollutant Mass Emitted}_{\text{RDE},k}}{\text{Distance Driven}_{\text{RDE},k}} \times RF_k$$

RF_k is a function of the distance-specific (g/km) CO_2 ratio r_k between the RDE and the WLTP (k = urban and k = total respectively) as shown in the adjacent graph and table.

For ICE and NOVC-HEV, r_k is computed as:

$$r_k = \frac{M_{\text{CO}_2, \text{RDE},k}}{M_{\text{CO}_2, \text{WLTP},k}}$$

with $M_{\text{CO}_2, \text{WLTP},k}$ defined in the adjacent table.

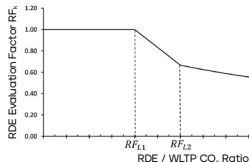
For OVC-HEV, r_k is computed as: $r_k = \frac{M_{\text{CO}_2, \text{RDE},k}}{M_{\text{CO}_2, \text{WLTP}_{\text{CS}},k}} \times \frac{0.85}{IC_k}$

with IC_k being defined as: $IC_k = \frac{\text{distance driven with the ICE on in total/urban}}{\text{total/urban distance}}$

The RDE evaluation factors are subject to review by the European Commission and shall be revised as a result of technical progress.

Relevant phases of WLTP to be used for $M_{\text{CO}_2, \text{WLTP},k}$

	k = urban	k = total
ICE	Low + medium speed	Whole WLTP cycle
NOVC-HEV	Whole WLTP cycle	
OVC-HEV	Whole WLTP cycle in charge sustaining mode	



When:	Then the result evaluation factor RF_k is:	Where:
$r_k \leq RF_{L1}$	$RF_k = 1$	
$RF_{L1} < r_k \leq RF_{L2}$	$RF_k = a_1 r_k + b_1$	$a_1 = \frac{RF_{L2} - 1}{[RF_{L2} \times (RF_{L1} - RF_{L2})]}$ $b_1 = 1 - a_1 RF_{L1}$
$r_k > RF_{L2}$	$RF_k = \frac{1}{r_k}$	

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EUROPEAN UNION - EURO 7

Overview

In April 2024, the European Parliament and Council adopted the Regulation (EU) 2024/1257, also called Euro 7.

Scope: M₁ & N₁.

Application dates: New type: 29/11/2026; All new vehicles: 29/11/2027.

Regarding emissions, Euro 7 is close to Euro 6e-bis.

Emissions procedures are equivalent to Euro 6e-bis and are based mainly on UNR154 / UNR168 and UNR 83 08.

The main changes are:

- OBM for NO_x & PM (cf OBD section for more details)
- Anti-Tampering: linked to OBM – The manufacturer now has the responsibility to identify when the emission system has been tampered with
- PN₁₀ for WLTC and RDE (with unchanged limit: 6×10^{11})
- Evaporative Emissions limit reduced from 2.0 g to 1.5 g/test (see EVAP section for details)

- On-board fuel consumption monitoring (OBFCM) will also be applied during ISC (or ISV) tests
- Environmental vehicle passport required
- Prohibition of Manipulation Devices and Strategies replaces the Euro 6 provision on Defeat Devices. The AES / BES approach is maintained
- Increase of lifetime:
 - Main lifetime increased to 160,000 km or 8 years, whichever comes first
 - Additional lifetime: after main lifetime and up to 200,000 km or 10 years, whichever comes first – with durability multiplier = 1.2 for gaseous pollutants

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EUROPEAN UNION - EURO 7

New provisions

In addition to standard tailpipe and evaporative emissions, Euro 7 also sets limits for:

- Brake particles (limits below are applicable until 2029)
 - New limits should be defined starting 2030 with PN limits added
 - In 2035, the limits for all M_1 and N_1 will be $PM_{10} \leq 3$ mg/km/vehicle), following UN GTR 24 limits and procedures

Powertrain technology	Brake particle emissions limits in mg/km				
	PEV ^a	OVC-HEV	NOVC-HEV	FCV/FCHV	ICEV
(PM_{10}) M_1 and N_1 , excluding N_1 , Class III	3	7	7	7	7
(PM_{10}) N_1 , Class III	5	11	11	11	11

^a PEV = pure electric vehicle.

- Tyre abrasion – limits are to be defined based on the testing methodologies developed in UN WP.29 for testing tyre abrasion in real world conditions

Battery energy based MPR	Start of life to 5 years or 100,000 km whichever comes first	Vehicles more than 5 years or 100,000 km, and up to whichever comes first of 8 years or 160,000 km
M_1 : OVC-HEV / PEV	80%	72%
N_1 : OVC-HEV / PEV	75%	67%



EUROPEAN UNION - DRIVING CYCLES

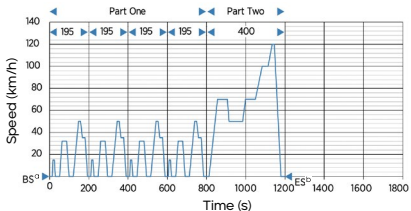
New European Driving Cycle (NEDC)

Urban (ECE) + Extra-Urban (EUDC) Cycle. Prior to Euro 3 (MVEG-A: ECE+EUDC)

- Bag sampling starts after the 40 sec. idle period

Cycle revision for Euro 3 onwards (MVEG-B: NEDC)

- Modification of the start-up phase: deletion of the 40 sec. idle period prior to bag sampling



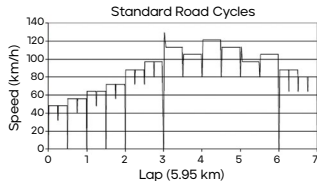
^aBS: Beginning of Sampling at engine start
^bES: End of Sampling

SRC - On-road durability test

The Standard Road Cycle (SRC) is a distance accumulation cycle on the vehicle.

The vehicle may be run on a test track or on a distance accumulation dynamometer.

The cycle consists of 7 laps of a 6 km course.



A first test is carried out when the vehicle has reached a distance of between 3,000 km and 5,000 km. Further tests are carried out at 20,000 km (± 400 km) and then every 20,000 km (± 400 km) or more frequently, at regular intervals until having covered the target useful life. Exhaust emissions are measured in accordance with the Type 1 Test.

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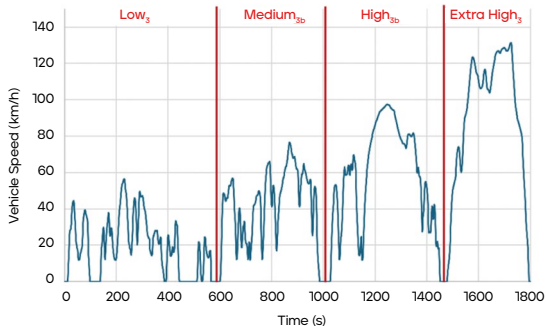
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EUROPEAN UNION - DRIVING CYCLES

WLTC profile showing the example of class 3b



Phase	Duration(s)	Phase	Duration(s)
Low Speed	589	High Speed	455
Medium Speed	433	Extra-High Speed	323
Tot. = 1,800 s			

Differences	MVEG-B	WLTC class 3b
Duration(s)	1,180	1,800
Length (km)	11.007	23.253
Environmental Temperature (C°)	20-30	23±5
Gear Shift	Fixed	Vehicle Specific
Idle Time (%)	21.8	13.1
V _{max} (km/h)	120	131.3
V _{average} (km/h)	33.6	46.5
Accel _{max} (m/s ²)	1	1.67

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EUROPEAN UNION - EURO 6

Emissions test procedure for all vehicles equipped with periodically regenerating systems

This requirement accounts for the higher emissions during periodic particulate filter regenerations.

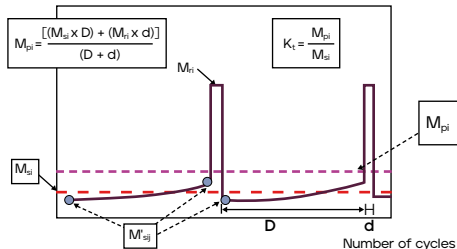
The vehicle, starting with an empty particulate filter, is driven on several WLTC cycles until a regeneration occurs. The emissions are measured during the cycles, both with and without regeneration.

The K_i (see below) term is then calculated using measured emissions, frequency and distance. The manufacturer may elect to determine for each compound independently either additive offsets or multiplicative factors, in both cases represented by K_i .

$$K_i \text{ factor: } K_i = \frac{M_{pi}}{M_{si}} \quad K_i \text{ offset: } K_i = M_{pi} - M_{si}$$

If the distance between two successive periodic regenerations is more than 4,000 km of driving repeated Type 1 tests, it does not require a special test procedure, and $K_i = 1$.

Emission factors for periodically regenerating systems



M_{pi} is the mean mass emissions of compound i , g/km.
 M_{ri} is the mean mass emissions of compound i during regeneration, g/km.
 M_{si} is the mean mass emissions of compound i without regeneration, g/km.
 d is the number of complete applicable test cycles required for regeneration.
 D is the number of complete applicable test cycles between two cycles where regeneration events occur.



US FEDERAL AND CALIFORNIA - VEHICLE CATEGORIES

Gross Vehicle Weight Rating (lbs)			
6,000		8,500	10,000
Light-duty vehicle (LDV) ^a		Medium-duty passenger vehicle (MDPV) ^{a,h}	
Light-duty truck (LDT) ^b			
Light light-duty truck (LLDT) ^c	Heavy light-duty truck (HLDT) ^d		
LDT 1 & 2 ^e	LDT 3 & 4 ^f		

^a LDV means a passenger car or passenger car derivative capable of seating 12 passengers or less.

^b California: LDT 1 LVW ≤ 3,750 lbs (same as federal); LDT 2 LVW 3,751 lbs to 8,500 lbs.

^c Also known as class 1.

^d Also known as class 2a.

^e LDT 1 if loaded vehicle weight (LVW) ≤ 3,750 lbs; LDT 2 if LVW > 3,750 lbs.

^f LDT 3 if adjusted loaded vehicle weight (ALVW) ≤ 5,750 lbs; LDT 4 if ALVW > 5,750 lbs.

^g Until 2026: vehicles designed primarily for the transportation of persons with a seating capacity of no more than 12 persons and with a cargo area of less than 72 inches.

- From MY 2027 (EPA): some pickups up to 14,000 lbs included (see 40 CFR 86.1803-01 and "Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles" preamble Section III.E).

^h MDPVs and trucks in this weight range also known as Class 2b.

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US FEDERAL (EPA) AND CALIFORNIA (CARB) - CHRONOLOGICAL OVERVIEW

Limits on FTP

	Name	From model year	NMHC (mg/mi)	NMOG (mg/mi)	NOx + NMOG (mg/mi)	NOx (mg/mi)	PM (mg/mi)	CO (g/mi)	HCHO (mg/mi)	Useful life at
			FTP 25°C							
Historical	EPA Tier 1 ^a	MY 1994	310	-	-	1,250 / 600 ^b	10 ^f	4.2	-	100,000 miles or 10 years
Historical	CARB LEV I ^a	MY 2003	-	90	-	300	8	4.2	18	100,000 miles or 10 years
Historical	EPA Tier 2 ^a	MY 2004	90 ^f	90 ^g	-	70	10	4.2	18	120,000 miles or 10 years
Historical	CARB LEV II	MY 2004	-	90	-	70	10	4.2	18	120,000 miles or 11 years
Current	EPA Tier 3 final	MY 2017	-	-	30 ^h	-	3 ^c	4.2 ^d	4	150,000 miles or 15 years
Current	CARB LEV III	MY 2015	-	-	30	-	3 ^e	1	4	150,000 miles or 15 years
Upcoming	EPA Tier 4 final	MY 2027	-	-	15 ⁱ	-	0.5	1.7	4	150,000 miles or 15 years
Revoked	CARB LEV IV	MY 2025	-	-	30 ^j	-	1 ^k	1.7	4	150,000 miles or 15 years

^a Limit for Full useful life - stricter limits for intermediate life (half miles / years).

^b Diesel / gasoline.

^c Certification standard - In-use value: 6 mg/mi.

^d On SFTP.

^e Phase in from 2017 to 2021.

^f Applicable to diesel only.

^g Applicable for gasoline only.

^h Phase-in from 2017 to 2025 (86 -> 30).

ⁱ Phase-in from 2027 to 2032 (30 -> 15).

^j Progressive ZEV phase-out for the fleet calculation.

^k Phase-in from 2025 to 2028.

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US FEDERAL - TIER 3 STANDARDS

Tier 3 standards overview

- Tier 3 emissions standards were adopted in March 2014 and phased in from 2017 to 2025. The regulation also tightened sulfur limits for gasoline
- Both the certification limits (Bins) and the fleet average standards are expressed using the sum of NMOG+NOx emissions
- The required emission durability was increased to 150,000 mi or 15 yrs whichever comes first
- Gasoline vehicles are tested – for exhaust and evaporative emissions – using gasoline containing 10% ethanol (E10)
- In-Use Verification Program (IUV) and In-Use Confirmatory Program (IUCP) to check the vehicle conformity in real life
- Provisions for carry-forward and carry-back of credits
- Provision for carry-over programs with respect to in-use testing
- Flex fueled vehicles are only required to provide assurance that the same emission reduction systems are used on non-gasoline fuel as on gasoline

Tier 3 Certification Bin Standards (FTP, 150,000 mi)

Bin	NMOG+NOx (mg/mi)	PM ^a (mg/mi)	CO (g/mi)	HCHO (mg/mi)
Bin 160	160	3	4.2	4
Bin 125	125	3	2.1	4
Bin 70	70	3	1.7	4
Bin 50	50	3	1.7	4
Bin 30	30	3	1.0	4
Bin 20	20	3	1.0	4
Bin 0	0	0	0	0

Tier 3 Federal and LEV III California were harmonized to create one set of limits for all 50 states.

^aIn MY 2017-20 the PM standard applies only to that segment of a manufacturer's vehicles covered by the percent of sales phase-in for that model year (see page 40).

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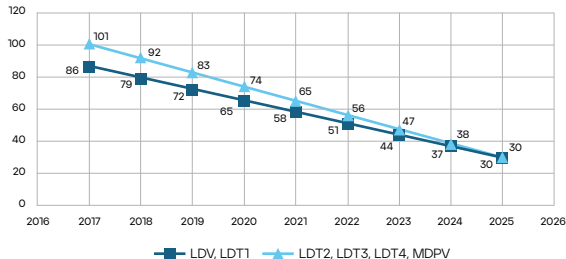


US FEDERAL - TIER 3 STANDARDS

Tier 3 fleet average NMOG+NOx FTP limit phase-in (mg/mi)

Each manufacturer's fleet must on average meet the following standards in each year.

For LDVs and LDTs over 6,000 lbs GVWR and MDPVs, the fleet average standards apply beginning in MY 2018.



Tier 3 SFTP^a fleet average phase-in for NMOG +NOx

Emission	2017	2018	2019	2020	2021	2022	2023	2024	2025
NMOG+NOx (mg/mi)	103	97	90	83	77	70	63	57	50
CO (g/mi)	4.2								

- Manufacturers self-select SFTP standards for each vehicle family (similar to bins)
- Self-selected standards not to exceed 180 mg/mi
- Average over whole fleet not to exceed tabulated values above

US06 is a dynamic cycle representative of aggressive driving with high accelerations (see annex).

SC03 is the cycle to take into account the air conditioning impact. The test is made at 35°C with A/C on (see annex).

^a Supplemental Federal Test Procedure - Results calculated with emissions measured on FTP-75, US06 & SC03 SFTP (mg/mi) = 0.35 x FTP (mg/mi) + 0.28 x US06 (mg/mi) + 0.37 x SC03 (mg/mi).



US FEDERAL - TIER 3 STANDARDS

Cold temperature standards

Cold temperature testing is conducted on the FTP cycle at -7° C for gasoline vehicles only to the following limits:

g/mi	CO	NMHC
PC & LDT1	10.0	0.3
LDT2	12.5	
LDT3 & LDT4		0.5

Other provisions

- Useful Life: The Clean Air Act prohibits useful life > 120,000 mi for LDV and LDT1. The 150,000 mi limit multiplied is voluntary. Tier 3 FTP limits at 120,000 miles are the respective 150,000 mi limit multiplied by 0.85 and rounding to nearest mg/mi. Limits for other cycles remain the same for both useful life periods
- High Altitude: Tier 3 standards allow limited relief at high altitude. Manufacturers may comply with one bin higher at altitude. Bin 70 is capped at 105 mg/mi and Bin 160 gets no relief at altitude

- Enrichment Limits: Enrichment for Otto-cycle (PI) engines throughout the US06 cycle is limited to lean best torque ÷ 1.04 (See 40 CFR 86.1811-17(d)(1))

Phase-in of Tier 3 PM FTP Standards (mg/mi)^a

Phase-in	2017	2018	2019	2020	2021	2022+
% of Sales	20	20	40	70	100	100

Phase-in of Tier 3 PM US06 Standards (mg/mi)^a

Phase-in	2017	2018	2019	2020	2021	2022	2023	2024+
% of Sales	20	20	40	70	100	100	100	100
Certification Standard	10	10	6	6	6	6	6	6
In-use Standard	10	10	10	10	10	10	10	6

^a Tier 3 PM standards apply to each vehicle category separately. In-use standard is relaxed until phase-in is complete.

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US FEDERAL - TIER 4 STANDARDS

Tier 4 standards

- Tier 4 emissions standards were adopted in March 2024 and phased-in from 2027 to 2032, significantly tightening pollutant standards as part of the "Multipollutant rule" that also includes greenhouse gas emission fleet average standards
- This rule is for light-duty emissions and applies also to medium-duty passenger vehicles (MDPV)
- Manufacturers must meet the NMOG+NOx fleet-average standards across four driving cycles (FTP, HFET, US06 and SC03) to ensure robust emissions control over a wide range of in-use driving conditions
- The standard:
 - adds more bin resolution at low-emission bins (bin 5, bin 10, bin 15 and intermediate, i.e. bin 25)
 - eliminates the highest certification bins
 - the fleet average includes all vehicles including battery electric
- A cold temperature (-7°C) FTP NMOG+NOx limit of 300 mg/mi is also applied
- The reduced PM limit 0.5 mg/mi must be met by each individual vehicle across 3 test cycles, including a cold temperature (-7°C) test. It is phased in from MY 2027 to MY 2030 for LDV (see chart)
- An HCHO limit is added on the standard FTP test
- The CO limit is reduced and is measured as NMOG + NOx, on all cycles

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US FEDERAL - TIER 4 STANDARDS

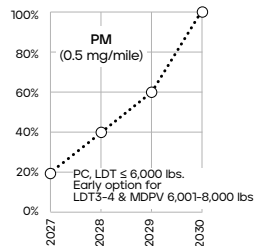
NMOG+NOx fleet-average emissions standards

Model year	Light-duty NMOG+NOx (mg/mi)
2026 (Tier 3 for reference)	30
2027	25
2028	23
2029	21
2030	19
2031	17
2032	15
2033 and later	15

Emissions limits

Test cycles	Light-duty (mg/mi)		
	PM	CO	HCHO
FTP 25°C / HFET / SC03	0.5	1,700	4
FTP -7°C	0.5	10,000	-
US06	0.5	9,600	-

Phase-in schedule for above PM standard



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CALIFORNIA - LEV III STANDARDS

LEV III standards overview

- LEV III standards phase-in 2015-2025 MY. Beginning 2020 MY all vehicles must be certified to LEV III
- Both the certification limits (bins) and fleet average standards are expressed as NMOG+NO_x
- The required emission durability has been increased to 150,000 miles from 120,000 miles

LEV III FTP standards

Passenger Cars and Light-Duty Trucks ≤ 8,500 lbs

Durability (mi)	Emission category	NMOG+NO _x (mg/mi)	CO (g/mi)	HCHO (mg/mi)	Particulates ^a (mg/mi)
150,000	LEV160	160	4.2	4	10
	ULEV125	125	2.1	4	10
	ULEV70	70	1.7	4	10
	ULEV50	50	1.7	4	10
	SULEV30	30	1.0	4	10
	SULEV20	20	1.0	4	10

- Standards apply at full useful life
- Alternatives exist for the phase-in of 3 mg/mi and 10 mg/mi PM standards

^a This limit shall apply only to the vehicles not included in the phase-in of particulate standards (see page 45).

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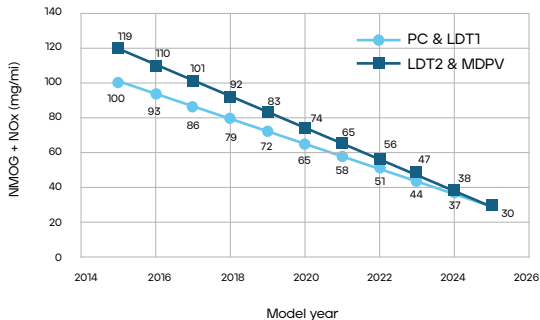
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CALIFORNIA - LEV III STANDARDS

LEV III NMOG + NOx fleet average phase-in



LEV III 50°F/10°C FTP standards

Light-Duty Trucks and Medium-Duty Passenger Vehicles must also demonstrate compliance with the following NMOG + NOx standards measured on FTP at 50°F.

Emission category	NMOG+ NOx (mg/mi)		HCHO (mg/mi)
	Gasoline	Alcohol fuel	Both gasoline & alcohol fuel
LEV160	320	320	30
ULEV125	250	250	16
ULEV70	140	250	
ULEV50	100	140	
SULEV30	60	125	8
SULEV20	40	75	



CALIFORNIA - LEV III STANDARDS

LEV III particulate phase-in schedule

Year	PC, LDT, MDPV	
	Percent of vehicles certified to:	
	PM = 3 mg/mi	PM = 1 mg/mi
2017	10	0
2018	20	
2019	40	
2020	70	
2021	100	
2022	100	

Year	PC, LDT, MDPV	
	Percent of vehicles certified to:	
	PM = 3 mg/mi	PM = 1 mg/mi
2023	100	0
2024	100	0
2025	75	25
2026	50	50
2027	25	75
2028	0	100

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CALIFORNIA - LEV III STANDARDS

LEV III SFTP individual standards

US06 and SC03 NMOG+NO_x and CO Stand-Alone Exhaust Emission Standards for MY 2015 onwards LEV III Passenger Cars, Light-Duty Trucks and Medium-Duty Passenger Vehicles

Vehicle type	Durability (mi)	Emission category ^a	US06 Test		SC03 Test	
			NMOG + NO _x (mg/mi)	CO (g/mi)	NMOG + NO _x (mg/mi)	CO (g/mi)
All PCs; LDTs 0-8,500 lbs GVWR; and MDPVs	150,000	LEV	140	9.6	100	3.2
		ULEV	120	9.6	70	3.2
		SULEV (Option A) ^b	60	9.6	20	3.2
		SULEV	50	9.6	20	3.2

^aEmission Category: Manufacturers must certify all vehicles, which are certifying to a LEV III FTP emission category on a 150,000 mi durability basis, to the emission standards of the equivalent, or a more stringent SFTP emission category. That is, all LEV III LEVs certified to 150,000 mi FTP emission standards shall comply with the SFTP ULEV emission standards, and all LEV III SULEV's certified to 150,000 mi FTP emission standards shall comply with the SFTP SULEV emission standards.

^bOptional SFTP SULEV Standards. A manufacturer may certify light-duty truck test groups from 6,001 to 8,500 lbs. GVWR and MDPV test groups to the SULEV, option A, emission standards set forth in this table for the 2015 through 2020 model year, only if the vehicles in the test group are equipped with a particulate filter and the manufacturer extends the particulate filter emission warranty mileage to 200,000 miles. Passenger cars and light-duty trucks 0-6,000 lbs. GVWR are not eligible for this option.

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CALIFORNIA - LEV III STANDARDS

SFTP NMOG+NOx and CO composite exhaust emission standards

- A manufacturer must certify LEV III (LEVs, ULEVs and SULEVs), such that the manufacturer's sales-weighted fleet average NMOG+NOx composite emission value, does not exceed the applicable NMOG+NOx SFTP composite emission standard
- The CO composite emission value of any LEV III test group shall not exceed the CO composite emission standard (see next page)
- SFTP compliance shall be demonstrated using the same gaseous or liquid fuel used for FTP certification
- From 2018, all multi-fueled vehicles shall comply with all requirements established for each consumed fuel (or blend of fuels for fuel-flexible vehicles). For each test group subject to this subsection, manufacturers shall calculate a Composite Emission Value for NMOG+NOx and, for LEV III test groups, a separate Composite Emission Value for CO, using the following equation:

$$\text{Value} = 0.28 \times \text{US06} + 0.37 \times \text{SC03} + 0.35 \times \text{FTP}$$

- where: US06 = the test group's NMOG+NOx for CO emission value, as applicable, determined through the US06 test
- where: SC03 = the test group's NMOG+NOx or CO emission value, as applicable, determined through the SC03 test
- where: FTP = the test group's NMOG+NOx or CO emission value, as applicable, determined through the std FTP test



CALIFORNIA - LEV III STANDARDS

LEV III SFTP fleet average phase-in

US06 and SC03 NMOG+NO_x and CO composite emission standards for MY 2015 onwards. Light-duty trucks and medium-duty passenger vehicles^a.

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025+
All PCs; LDTs 0- 8,500 lbs GVWR; and MDPVs	Sales-Weighted Fleet Average NMOG+NO _x Composite Exhaust Emission Standards (mg/mi)										
	140	110	103	97	90	83	77	70	63	57	50
	CO Composite Exhaust Emission Standard (g/mi)										
	4.2										

^a Mileage for compliance: all test groups certifying LEV III FTP emission standards on a 150,000 mi durability basis shall also certify to the SFTP on a 150,000 mi durability basis, as tested in accordance with these test procedures.

LEV III SFTP PM standards

SFTP PM exhaust emission standards for MY 2017 onwards LEV III. Passenger cars, light-duty trucks and medium-duty passenger vehicles^b.

Vehicle type	Test weight	Durability	Test cycle	PM (mg/mi)	
				2018 and prior	2019+
All PCs; LDTs 0-8,500 lbs GVWR; MDPVs	Loaded vehicle weight	150,000	US06	10	6

^b All PCs, LDTs and MDPVs certified to LEV III FTP PM emission standards on a 150,000 mi durability basis shall comply with the SFTP PM Exhaust Emission Standard.

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CALIFORNIA - LEV IV STANDARDS (REVOKED)

LEV IV developments

CARB developed LEV IV as part of the Advanced Clean Cars II (ACC II) program to reduce emissions from ICE vehicles. The final text was adopted in November 2022 with the first introduction for MY 2025.

In June 2025, the President signed a resolution under the Congressional Review Act that revoked three California emissions waivers, including the one for ACC II, and that prevents "substantially similar" rules being implemented in future. LEV IV is therefore currently not due for implementation. The legality of the resolution is being challenged in court.

The following summary is included for orientation.

1. Bin structure

Emission category	NMOG+NO _x ^a	CO
	mg/mi	g/mi
ULEV125	125 / 160	4.2
ULEV70	70 / 105	2.1
ULEV60	60 / 90	1.7
ULEV50	50 / 70	1.7
ULEV40	40 / 60	1.7
SULEV30	30 / 50	1.0
SULEV25	25 / 50	1.0
SULEV20	20 / 30	1.0
SULEV15	15 / 30	1.0

^a Standards at low / high altitude.

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CALIFORNIA - LEV IV STANDARDS (REVOKED)

2. NMOG + NOx fleet average

- A combined NMOG + NOx fleet average of 30mg/mi applies to PC, LDT and MDPV vehicle categories
- ZEVs and emission-adjusted PHEVs are included in the fleet average calculation with the ZEV part counted as zero, phased out according to the following schedule:

MY	2025	2026	2027	2028	2029
ZEV in fleet average (%)	100%	60%	30%	15%	0

- Certification Bins are revised
 - LEV 160 only available through MY 2025
 - ULEV 125 only available through MY 2028
 - Existing ULEV 70, ULEV 50, SULEV 30 and SULEV 20 bins will be supplemented with new bins of ULEV 60, ULEV 40, SULEV 25 and SULEV 15

3. Particulate Matter Standards

- Target of 1 mg/mi for all vehicles on FTP phased in as below

MY	2026	2027	2028
ZEV in fleet average (%)	50	75	100

Pure ZEVs are excluded from the requirement and phase-in.

4. Aggressive Driving Emission Standards

- Option to use composite standards for certification will be removed
- New US06 NMOG + NOx fleet average standard will be equal to FTP standard at 0.03 g/mile with altered bins and phase-in to 2030
- US06 PM standard 3mg/mile with phase-in to 2028
- Attestation for SC03 standards
- Phase-in Schedule will apply

MY	2026	2027	2028
Phase-in (%)	30	60	100



CALIFORNIA - LEV IV STANDARDS (REVOKED)

5. Additional provisions

- Additional NMOG+NOx emission tests for 10-minute, 30-minute, and 3-to-12-hour partial soaks, by attestation
- Quick drive away standard with 8 second idle, altered bins and phase-in to 2028

6. PHEV High Power Cold-Start Emissions

- New cold-start US06 Certification test added
- PHEVs capable of running US06 without ICE use will be exempt



US FEDERAL - TIER 2 STANDARDS

Tier 2 standards overview

- Tier 2 standards were phased in from 2004-2009
- Same standards applicable to cars and trucks up to 8,500 lbs GVWR (most sport utility vehicles, pickup trucks and vans)
- Tier 2 also added Medium-Duty Passenger Vehicles (MDPV) from 8,500 lbs to 10,000 lbs GVWR into the normal requirement
- Vehicles up to 8,500 lbs GVWR must also meet Tier 2 limits on Supplemental Federal Test Procedure (SFTP)
- Emissions limits are fuel neutral, i.e. applicable to gasoline, diesel and all other fuels
- NOx fleet average of 0.07 g/mi is fully phased in from 2009 and must be met at 120,000 mi / 10 yrs
- Any of the 8 standard 'bins' can be used for a specific vehicle provided the total fleet average NOx emissions are within the 0.07 g/mi limit
- Temporary 'bins' expired in 2006 for LD vehicles and LD trucks and in 2008 for HLD trucks and MD Passenger vehicles
- In lieu of intermediate useful life standards (50,000 mi) or to gain additional nitrogen oxides credit, manufacturers may optionally certify to the Tier 2 emission standards with a useful life of 150,000 mi
- Test covered: Federal Test Procedures (FTP), cold carbon monoxide, highway and idle MY > 2004+

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US FEDERAL - TIER 2 STANDARDS

Bin structure for passenger cars, light-duty trucks and medium-duty passenger vehicles

Standard	Emissions limits (50,000 mi)					Emissions limits at full useful life (120,000 mi)				
	NOx (mg/mi)	NMOG (mg/mi)	CO (g/mi)	PM (mg/mi)	HCHO (mg/mi)	NOx (mg/mi)	NMOG (mg/mi)	CO (g/mi)	PM (mg/mi)	HCHO (mg/mi)
Bin 1	-	-	-	-	-	0	0	0	0	0
Bin 2	-	-	-	-	-	20	10	2.1	10	4
Bin 3	-	-	-	-	-	30	55	2.1	10	11
Bin 4	-	-	-	-	-	40	70	2.1	10	11
Bin 5	50	75	3.4	-	15	70	90	4.2	10	18
Bin 6	80	75	3.4	-	15	100	90	4.2	10	18
Bin 7	110	75	3.4	-	15	150	90	4.2	20	18
Bin 8 ^a	140	100 / 125	3.4	-	15	200	125 / 156	4.2	20	18

^a Pollutants with two numbers have a separate certification standard (1st number) and in-use standard (2nd number).

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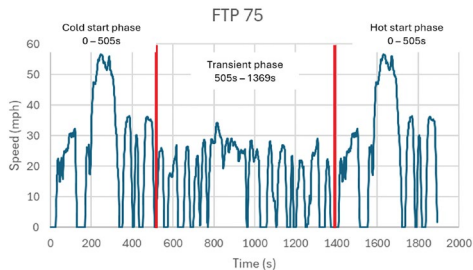
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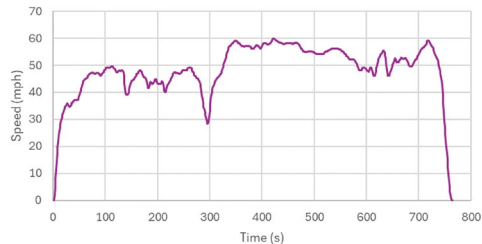
US FEDERAL AND CALIFORNIA

City driving cycle^a



Total duration: 1,874 sec. (+hot soak: 540 sec. min., 660 sec. max.)
 Length: 11.04 mi (17.77 km)
 Average speed: 21.19 mph (34.2 km/h – stop excluded)
 Simultaneous engine crank and bag sampling start. Initial idle is 20 sec.
 Max. speed: 56.68 mph (91.2 km/h)
 Between Phase II and Phase III, Hot Soak (9-11 min.)

HWFET (Highway Fuel Economy Driving Schedule)



Total duration: 765 sec.
 Length: 10.26 mi (16.5 km)
 Average speed: 48.30 mph (77.7 km/h)
 Max. speed: 59.91 mph (96.4 km/h)

^a Also known as FTP 75, EPA III – Phase I + II, also known as: FTP 72, EPA II, UDDS, LA-4.

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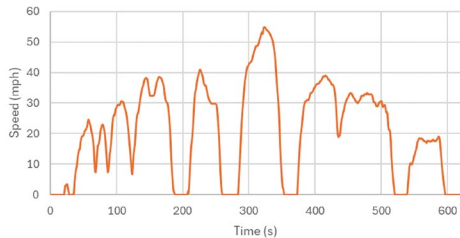
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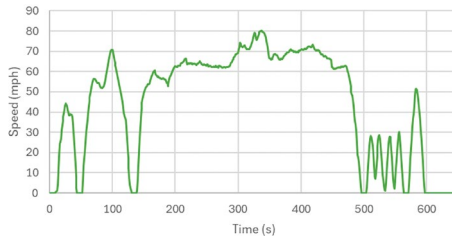
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SCO3 Air Conditioning Driving Cycle



Total duration: 598 sec.
 Length: 3.58 mi (5.76 km)
 Average speed: 21.55 mph (34.9 km/h)
 Max. speed: 54.8 mph (88 km/h)
 Initial idle: 18 sec.

US06 High Speed/High Load Driving Cycle



Total duration: 596 sec.
 Length: 8.01 mi (12.86 km)
 Average speed: 48.37 mph (77.2 km/h)
 Max. speed: 80.03 mph (129 km/h)
 Initial idle: 5 sec.
 Max. acceleration: 8 mph/s

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PR OF CHINA - OVERVIEW

Overview of standards

Chinese emission standards for passenger cars and light-duty commercial vehicles up to China 5 are based on European regulations.

Vehicle classification

It is based on the EU classification, with some differences.

Category	Class	Mass ^e	EU reference
Type 1	-	GVW ≤ 2,500 kg	M ₁ vehicles for no more than 6 passengers including driver
Type 2	I	RM ≤ 1,305 kg	Other light-duty vehicles (including N ₁ light commercial vehicles)
	II	1,305 kg < RM ≤ 1,760 kg	
	III	RM > 1,760 kg	

Implementation dates

Stage/Standard		Reference	Region	Implementation dates	
				NT	NV
CN4 GB 18352.3-2005		Euro 4	Nationwide	1 Jul 2010	PI: 1 Jul 2011 CI: 1 Jan 2015
			Beijing (B4)	1 Mar 2008	
			Shanghai	1 Nov 2009	
CN5 GB 18352.5-2013		Euro 5	Nationwide	1 Apr 2016 ^{a,b} 1 Jan 2017 ^a 1 Jan 2018 ^c	
			Beijing (B5)	PI w/o IUPR, CI: 1 Feb 2013 PI w/ IUPR: 1 Jan 2015	
			Shanghai	1 May 2014 ^{a,d}	
CN6a	GB 18352.6-2016	Euro 6	Nationwide	1 Jul 2020	
CN6b			Nationwide	1 Jul 2023	

^a Light-duty gasoline vehicles and public buses, sanitary and postal vehicles.

^b In 11 Eastern provinces only (Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan).

^c All vehicles.

^d Gasoline vehicles.

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PR OF CHINA - CHINA 6 STANDARD

China 6 (CN6) - emission limits

China 6 standards are fuel neutral, same limits apply for gasoline and diesel vehicles. CN6 emissions testing is to be carried out over the WLTP cycle.

Unlike Euro 6, an N₂O limit is applied.

Stage	Category	Class	CO	THC	NMHC	NOx	N ₂ O	PM	PN ^a
			g/km						#/km
CN6a	Type 1		0.70	0.10	0.068	0.060	0.020	0.0045	6×10 ¹¹
	Type 2	I	0.70	0.10	0.068	0.060	0.020	0.0045	6×10 ¹¹
		II	0.88	0.13	0.090	0.075	0.025	0.0045	6×10 ¹¹
		III	1.00	0.16	0.108	0.082	0.030	0.0045	6×10 ¹¹
CN6b	Type 1		0.50	0.050	0.035	0.035	0.020	0.0030	6×10 ¹¹
	Type 2	I	0.50	0.050	0.035	0.035	0.020	0.0030	6×10 ¹¹
		II	0.63	0.065	0.045	0.045	0.025	0.0030	6×10 ¹¹
		III	0.74	0.080	0.055	0.050	0.030	0.0030	6×10 ¹¹

^aPN limit of 6×10¹² applied to gasoline vehicles until July 2020.

China 6 - real driving emissions (RDE)

- CN6b includes a RDE test based on Euro 6 RDE with conformity factors of CF = 2.1 both for NOx and PN
- RDE emissions test conformity are applicable to all vehicles from July 2023. Until July 2023, RDE tests results were monitored and reported
- The cold start period is recorded but excluded from RDE data evaluation
- A further extended condition is added for altitude comprised between 1,300 m and 2,400 m with an emission corrective factor of 1 / 1.8
- MAW data evaluation method is used

The payload during an RDE test can vary, but is never more than 90% of the vehicle's maximum load.

Ambient condition	Moderate	Extended	Further extended
Emissions corrective factor	1	1 / 1.6	1 / 1.8
Temperature	0 ≤ T ≤ 30°C	-7 ≤ T < 0°C; 30 < T ≤ 35°C	-
Altitude	≤ 700 m	700 < Alt ≤ 1,300 m	1,300 < Alt ≤ 2,400 m

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PR OF CHINA - CHINA 6 STANDARD

Trip composition and validation parameters are close to those applied in EU.

- Specific boundary conditions presented in page 57
- Same trip requirement & composition – please refer to EU part page 26
- Same driving dynamics criteria – please refer to EU part page 27
- Same method for CO₂ characteristic curve (please refer to EU part page 28), but specific Reference Point

Vehicle CO₂ characteristic curve

WLTC phases	Low-speed (LS)	High-speed (HS)	Extra-high speed (EHS)
Reference point	P1	P2	P3
Reference point: Speed (km/h)	19 km/h	56.6 km/h	92.3 km/h
Reference point: CO ₂ (g/km)	1.2 x CO ₂ LS-WLTP	1.1 x CO ₂ HS-WLTP	1.05 x CO ₂ EHS-WLTP

- Specific verification of overall trip dynamics with different upper tolerances and condition of completeness: When the number of urban, rural and motorway windows accounts for more than 15% of the total number of windows respectively, the test is considered to be completed

Trip dynamics parameters

	Urban	Rural	Motorway
Windows bins thresholds	Speed < 45 km/h	$45 \leq \text{Speed} < 80$ km/h ^a	$80^{\circ} \leq \text{Speed} < 145$ km/h
Completeness	$\geq 15\%$	$\geq 15\%$	$\geq 15\%$
Tolerance around CO ₂ characteristic curve			
Upper tolerance	+ 50% ^b		
Lower tolerance	- 25%		
% of windows within the tolerance band			
RDE test valid if	$\geq 50\%$	$\geq 50\%$	$\geq 50\%$

^a 70 km/h for N₂ vehicle with 90 km/h speed limiting device.

^b The upper tolerance may be increased by steps of 1% until 50%.



PR OF CHINA - CHINA 6 STANDARD

China 6 - durability requirements

Deterioration factors or values are used to comply with emissions limits during Type I test. They can be determined by one of the following three methods:

- Whole vehicle ageing test of 160,000 km for CN6a and 200,000 km for CN6b (During transition period to 1 July, 2023 160,000 km is applied)
- Engine bench ageing durability test
- Application of the assigned multiplicative or additive deterioration factors from the following tables

Durability: Assigned multiplicative deterioration factors (CN6)

Engines	CO	THC	NMHC	NOx	N ₂ O	PM	PN
PI	1.8	1.5	1.5	1.8	1	1	1
CI	1.5	-	-	1.5	1	1	1

Durability: Assigned additive deterioration factors (CN6)

Engines	CO	THC	NMHC	NOx	N ₂ O	PM	PN
PI	6a	150	30	20	25	0	0
	6b	110	16	10	15	0	0
CI	6a	150	-	-	25	0	0
	6b	110	-	-	15	0	0

The manufacturer may use the deterioration correction values of Type IV tests as specified below.

Category	Deterioration values
Test type IV	0.06 g/test



PR OF CHINA - CHINA 6 STANDARD

Test type III - crankcase emissions

Any gas in the engine crankcase is not allowed to be directly discharged into the atmosphere. If the crankcase exhaust is introduced into the upstream exhaust of the exhaust aftertreatment device (closed) under all operating conditions, the crankcase exhaust is deemed to meet the requirements. Otherwise, the crankcase discharge should be introduced into the emission sampling system and tested according to the evaluation method of the crankcase pollutants. If the emission test results meet the limit requirements, then the crankcase emissions meet the standard requirements.

Engine operating conditions for the crankcase emissions test

Operating condition	Speed (km/h)	Power absorbed by the chassis dynamometer
1	Idle	None
2	50±2 (Gear 3 or forward gear)	Equivalent to the adjusting state under 50 km/h in Type I test
3	50±2 (Gear 3 or forward gear)	Set value of condition 2 multiplied by 1.7

Test type VI - low temperature test (-7°C)

CN6 includes a low temperature emissions test at -7°C +/-3°C to be carried out with a cold start over the low and medium speed phases of the WLTC, applicable to both gasoline and diesel vehicles.

Cold-start emission limits

Stage	Category	Class	CO g/km	THC g/km	NOx g/km
CN6	Type 1		10	1.20	0.25
	Type 2	I	10	1.20	0.25
		II	16	1.80	0.50
		III	20	2.10	0.80

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PR OF CHINA - CHINA 7 STANDARD

China 7

China 7 is currently under development.

Implementation: Nationwide implementation planned in 2029.

The final draft is expected end of 2025 for public consultation.

Key areas requiring further specification may include:

- Simultaneous reductions in GHG and criteria pollutant emissions (new pollutants as NH_3 , NMOG, PN_{10})
- Possible limit values for HC + NOx: 40 mg/km for passenger cars, 60 mg/km for light commercial vehicles
- NEVs inclusion in the regulatory framework to better reflect the fleet mix (battery durability...)
- Testing methodologies and data processing protocols review for Real Driving Emissions (RDE) testing (cold start / low load considerations, new compliance tools)
- EVAP testing stringency (including refuelling)
- Non-exhaust (brake and tyres) PM emissions limits
- Enhanced OBD

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PR OF CHINA - CHINA 4 & 5 STANDARDS

China 4 - China 5 emission standards - positive ignition engines

Stage	Category	Class	CO	THC	NMHC	NOx	PM	PN
			g/km					#/km
CN4	Type 1		1.00	0.10	-	0.08	-	-
	Type 2	I	1.00	0.10	-	0.08	-	-
		II	1.81	0.13	-	0.10	-	-
		III	2.27	0.16	-	0.11	-	-
CN5	Type 1		1.00	0.10	0.068	0.060	0.0045 ^a	-
	Type 2	I	1.00	0.10	0.068	0.060	0.0045 ^a	-
		II	1.81	0.13	0.090	0.075	0.0045 ^a	-
		III	2.27	0.16	0.108	0.082	0.0045 ^a	-

- From CN1 to CN5, testing is to be carried out over the NEDC cycle
- Durability requirements are 5 years or 100,000 km for CN4 and 160,000 km for CN5

^a Applies only to direct injection positive ignition engines.

China 4 - China 5 emission standards - compression ignition engines

Stage	Category	Class	CO	THC + NOx	NOx	PM	PN
			g/km				#/km
CN4	Type 1		0.50	0.30	0.25	0.025	-
	Type 2	I	0.50	0.30	0.25	0.025	-
		II	0.63	0.39	0.33	0.040	-
		III	0.74	0.46	0.39	0.060	-
CN5	Type 1		0.50	0.230	0.180	0.0045	6x10 ¹¹
	Type 2	I	0.50	0.230	0.180	0.0045	6x10 ¹¹
		II	0.63	0.295	0.235	0.0045	6x10 ¹¹
		III	0.74	0.350	0.280	0.0045	6x10 ¹¹



PR OF CHINA - CHINA 4 & 5 STANDARDS

China 4 - China 5 emission standards - compression ignition engines (cont.)

Durability: Assigned deterioration factors (CN4)

Engines	CO	HC	NOx	HC + NOx	PM
PI	1.2	1.2	1.2	-	-
CI	1.1	-	1.0	1.0	1.2

Durability: Assigned deterioration factors (CN5)

Engines	Durability: Assigned deterioration factors (CN5)						
	CO	THC	NMHC	NOx	THC + NOx	PM	PN
PI	1.5	1.3	1.3	1.6	-	1.0	-
CI	1.5	-	-	1.1	1.1	1.0	1.0

China 5 - low temperature test (-7°C)

CN5 includes a low temperature emissions test at -7°C to be carried out with a cold start over four urban cycles of the NEDC, applicable to gasoline vehicles.

Stage	Category	Class	CO	THC
			g/km	
CN5	Type 1		15	1.80
	Type 2	I	15	1.80
		II	24	2.70
		III	30	3.20



INDIA - BHARAT STAGE VI

Overview of standards

India follows European standards, with some adaptations to suit the local environmental conditions. Vehicle categories are the same as the corresponding Euro standard. India applies the Modified India Driving Cycle (MIDC), which is NEDC with maximum speed limited to 90 km/h.

Current Regulation in India is BS VI-2, very close to Euro 6d.

BS VI-3 applies an adapted version of WLTC (see page 69).

Implementation dates (nationwide)

Standard	Sub standards	Date	Emission cycle	RDE	Legislation ref.
BS VI (ref. Euro 6)	BS VI-1	1 April 2020	MIDC	Monitoring	AIS 137 (Part 3)
	BS VI-2	1 April 2023	MIDC	CF NO _x = 1.43 CF PN = 15	AIS 137 (Part 3)
	BS VI-3	1 April 2027	WLTC 3 phases ^a	CF NO _x = 1.43 CF PN = 15	AIS 175

^a Also called iWLTC.

In-service conformity (ISC) testing:

- Max. mileage: 100,000 km or 5 years
- Type I Tailpipe Emissions + OBD (IUPR)

Deterioration factors

Engine category	BS VI: Assigned deterioration factor						
	CO	THC	NMHC	NO _x	HC+NO _x	PM	PN
PI	1.5	1.3	1.3	1.6	-	1	1
CI	1.5	-	-	1.1	1.1	1	1

- In case of PI engines, PM and PN deterioration factors shall apply only to vehicles using direct injection
- For the deterioration factor evaluation, manufacturers may alternatively perform a vehicle ageing test of 160,000 km or bench ageing durability test, as per AIS-137

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INDIA - BHARAT STAGE VI

BS VI emission standards - positive ignition

Stage	Vehicle			CO	THC	NMHC	NOx	PM ^a	PN ^{a,b}
	Category	Class	Ref. mass (RM) (kg)	mg/km					#/km
BS VI	M (M ₁ & M ₂)	-	All	1,000	100	68	60	4.5	6×10 ¹¹
	N ₁	I	RM ≤ 1,305	1,000	100	68	60	4.5	6×10 ¹¹
		II	1,305 < RM ≤ 1,760	1,810	130	90	75	4.5	6×10 ¹¹
		III	RM > 1,760	2,270	160	108	82	4.5	6×10 ¹¹
	N ₂	-	All	2,270	160	108	82	4.5	6×10 ¹¹

^a Applies only to direct injection positive ignition engines.

^b Until three years after date of implementation for new type approvals and new vehicles, PN limit of 6×10¹² /km shall apply to BS VI PI DI vehicles upon choice of the manufacturer.

BS VI emission standards - compression ignition

Stage	Vehicle			CO	THC + NOx	NOx	PM	PN
	Category	Class	Ref. mass (RM) (kg)	mg/km				#/km
BS VI	M (M ₁ & M ₂)	-	All	500	170	80	4.5	6×10 ¹¹
	N ₁	I	RM ≤ 1,305	500	170	80	4.5	6×10 ¹¹
		II	1,305 < RM ≤ 1,760	630	195	105	4.5	6×10 ¹¹
		III	RM > 1,760	740	215	125	4.5	6×10 ¹¹
	N ₂	-	All	740	215	125	4.5	6×10 ¹¹

In case of PI engines, PM and PN factors shall apply only to vehicles using direct injection. For the deterioration factor evaluation, manufacturers may alternatively perform a vehicle ageing test of 160,000 km or bench ageing durability test, as per AIS-137.



INDIA - BHARAT STAGE VI

Real driving emissions

Major part of RDE methodology is coming from Euro 6c (RDE pack 3), but India has added some country specificities described here. Everything that is common is described in the Europe section.

RDE is currently not tested during ISC.

RDE - conformity factors in two steps

BS VI	Date	NOx	PN
BS VI - 1	April 2020	Monitoring	
BS VI - 2	April 2023	1 + margin NOx = 1 + 0.43	1 + margin PN = 1 + 0.5

RDE - boundary conditions of a valid trip

Ambient condition	Moderate	Extended
Emissions correction factor	1	1 / 1.6
Temperature	10 ≤ T ≤ 40°C	8 ≤ T 10°C; 40 < T ≤ 45°C
Altitude	≤ 700 m	700 < Alt ≤ 1,300 m

RDE - trip requirement for a valid RDE test

Driving portion	Urban	Rural	Motorway
	Speed ≤ 45 km/h ^b	45 < Speed ≤ 65 km/h ^c	65 km/h < Speed ^d
Minimum distance	16 km	16 km	16 km
Distance share ^e	34 (+/-10%)	33 (+/-10%)	33 (+/-10%)
Total trip duration	90 - 120 minutes		
Average speed including stops	15 < Avg. < 30 km/h	-	-
Total stop time (v < 1 km/h)	6 - 30% Urban time	-	-
Individual stop time	≤ 300 sec.	-	-
v > 75 km/h ^a	-	-	≥ 5 min.
v > 100 km/h	-	-	< 3% Motorway time

^a 70 km/h for N₁ vehicles and 55 km/h for Low Powered vehicles.

^b Valid for M₁ & N₁ low powered vehicles - 40 km/h for N₁.

^c Valid for M₁ & N₁ low powered vehicles - 40 km/h < Speed < 60 km/h for N₁.

^d Valid for M₁ - 60 km/h for N₁ - N/A for N₁ low powered vehicles.

^e For low powered vehicles: 50% Urban / 50% Rural.

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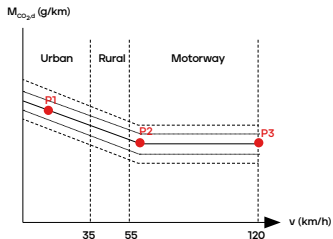
INDIA - BHARAT STAGE VI

1. RDE - driving dynamics criteria

- Criteria on driving dynamics are similar to EU (see EUROPE section page 27)

2. RDE - vehicle CO₂ characteristic curve

- The India RDE uses the first EU RDE methodology for the analysis (called pack 3 RDE)
- The first step consists of building the CO₂ mass characteristic curve:



Vehicle CO₂ mass characteristic curve

WLTC phases	Low-speed (LS)	High-speed (HS)	Extra-highspeed (EHS)
Reference point	P1	P2	P3
Reference point: Speed (km/h)	19 km/h	59.3 km/h	120 km/h
Reference point: Mass CO ₂ (g/km)	Mass CO ₂ MIDC Ph1 / 1.1	Mass CO ₂ MIDC Ph2/ 1.1	Mass CO ₂ MIDC Ph2/ 1.1

- Then, using PEMS 1 Hz data, moving average windows method is used to define windows with CO₂ equal to 100% CO₂ mass generated during the entire MIDC
- In each window, vehicle speeds and CO₂ emissions (expressed in g/km) are averaged, and plotted as a point together with the vehicle CO₂ characteristic curve obtained from the MIDC test



INDIA - BHARAT STAGE VI

3. RDE - verification of overall trip dynamics

- Unlike in Europe, the MAW method is used not only to evaluate the validity of the trip, but also to adjust emissions based on the position on the CO₂ characteristic curve
- The trip is divided into urban, rural and motorway parts based on speed as defined in following table

	Urban	Rural	Motorway
Windows bins thresholds	Speed < 35 km/h	35 ≤ Speed < 55 km/h	55 ≤ Speed < 120 km/h
Tolerance around CO₂ characteristic curve			
Tolerance 1 (Tol ₁) (High & Low)	+ / - 25% - Could be extended to 30%		
Tolerance 2 (Tol ₂) (High & Low)	+ / - 50%		

- The test shall be complete when it comprises at least 10% of urban, rural and motorway windows, out of the total number of windows for all categories of vehicles

- The test shall be considered valid when at least 50% of the urban, rural and motorway windows are within the primary tolerance defined for the characteristic curve

4. RDE - final emissions calculation

- Emissions are calculated for each Window:

$$M_{\text{gas},dk} = \frac{\sum(w_j M_{\text{gas},dj})}{\sum w_j} \text{ where } k = \text{urban, rural and motorway}$$

- The weighing factor w_j , for each window, is dependent on the average CO₂ measured in this window vs. the average vehicle speed:
 - If the value is within Tolerance 1, $w_j = 1$ (no correction)
 - If the value is between Tolerance 1 and Tolerance 2, w_j is interpolated between the values 1 and 0
 - If the value is outside Tolerance 2, $w_j = 0$



INDIA - STANDARDS IN PLANNING

WLTC introduction (AIS 175)

WLTC will be introduced in April 2027 with a complete update of Type I procedure mainly coming from UNR154 (including update on road load determination, Gear Shift pattern).

The reference cycle is WLTC 3 phases, excluding the Extra-High phase

Category		PMR (W/kg)	Speed phases
Class 3	3a ($V_{\max} < 120$ km/h)	PMR > 34	Low ₃ +Medium _{3b} +High _{3b}
	3b ($V_{\max} \geq 120$ km/h)		Low ₃ +Medium _{3a} +High _{3a}
Class 2		22 < PMR ≤ 34	Low ₂ +Medium ₂ +High ₂
Class 1		PMR ≤ 22	Low ₁ +Medium ₁ +High ₁

The RDE will also be impacted with the reference cycle changing from MIDC to WLTC. Furthermore, the post-processing will follow the European one (pack 4 - UNR168 - see Europe section):

- The MAW are used only to assess the validity of the trip
- Tol₁ is changed & Tol₂ is not used anymore
- The final RDE correction (R_k) is applied

The country-specific details (trip composition and temperatures) will remain the same as they are in BS VI.

CF will not change.

BS7

Based on the directions of SCOE (Standing Committee on Emissions) and AISC (Automotive Industry Standard committee), various panels and subgroups have been formed on different BS-7 topics to study Euro 7 directive 1257/2024 and prepare the draft for BS7 regulation, with members from Industry and Associations.

Main scope of the sub-panels will be to study the Euro-7 regulations and procedure and formulate equivalent AIS for BS-7 norms.

Based on the current AIS-175 document as the base, AIS n°215 is allotted for BS-7:

- Part-1: Light Duty Vehicles
- Part-2: Heavy Duty Vehicles

Schedule - AIS 215 draft document D0 by Q2 of 2026.

Currently the planned date for LDV implementation is 2029.

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INDIA – BHARAT STAGE IV

Overview

Starting from 1 June 1999 in NCR^a and in other cases 1 April 2000, for both four-wheeled LD and HD vehicles, India adopted European regulations concerning emissions and fuel consumption (BS-I).

Implementation dates

Standard	Date	Region
BS IV (ref. Euro 4)	01 April 2010	NCR ^a , 13 cities ^{b,c}
	01 July 2015	Above plus 29 cities ^d
	01 Oct 2015	North India + bordering districts of Rajasthan (9 States)
	01 April 2016	Western India + parts of South and East India (10 States and Territories)
	01 April 2017	Nationwide
BS V (ref. Euro 5)	Initially proposed in November 2015 but removed from a February 2016 proposal, transitioning the nation directly from BS IV to BS VI	

^a National Capital Region (Delhi).

^b Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Secunderabad, Ahmedabad, Pune, Surat, Kanpur and Agra.

^c Above cities plus Solapur and Lucknow. The program was later expanded with the aim of including 50 additional cities by March 2015.

^d Mainly in the states of Haryana, Uttar Pradesh, Rajasthan and Maharashtra.

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INDIA - BHARAT STAGE IV

Emission standards

Emissions cycle: MIDC

Stage	Vehicle			CO	THC + NOx ^a	NOx	PM
	Category	Class	Ref. mass (RM) (kg)	CI / PI mg/km			
BS IV	M (GVW ≤ 2,500 kg or less than 6 seaters)	-	All	500 / 1,000	300 / 100 ^a	250 / 80	25 / -
	N ₁ & M (GVW > 2,500 kg or more than 6 seaters)	I	RM ≤ 1,305	500 / 1,000	300 / 100 ^a	250 / 80	25 / -
		II	1,305 < RM ≤ 1,760	630 / 1,810	390 / 130 ^a	330 / 100	40 / -
		III	RM > 1,760	740 / 2,270	460 / 160 ^a	390 / 110	60 / -

^a Only THC were measured for PI engine.

The durability of anti pollution device is determined either by an actual durability run over 80,000 km or by application of assigned deterioration factors.

Engine category	BS IV: Assigned deterioration factor				
	CO	THC	NOx	HC + NOx	PM
PI	1.2	1.2	1.2	-	-
CI	1.1	-	1.0	1.0	1.2

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Emission standards - gasoline and LPG

			Test mode	Unit	CO	NMHC	NOx	PM ^a	PN ^m
New Short Term	2000	Passenger Car	10-15 Mode	g/km	0.67	0.08	0.08	-	-
			11 Mode	g/test	19.0	2.20	1.40		
	2002	Mini Commercial Vehicle	10-15 Mode	g/km	3.30	0.13	0.13		
			11 Mode	g/test	38.0	3.50	2.20		
	2000	Light Commercial Vehicle (GVW ≤ 1.7 t)	10-15 Mode	g/km	0.67	0.08	0.08		
			11 Mode	g/test	19.0	2.20	1.40		
	2001	Medium Commercial Vehicle (1.7 t < GVW ≤ 3.5 t)	10-15 Mode	g/km	2.10	0.08	0.13		
			11 Mode	g/test	24.0	2.20	1.60		
New Long Term	2005	Passenger Car	JC08	g/km	1.15	0.05	0.05	-	-
	2007	Mini Commercial Vehicle			4.02				
	2005	Light Commercial Vehicle (GVW ≤ 1.7 t)			1.15				
	2005	Medium Commercial Vehicle (1.7 t < GVW ≤ 3.5 t)			2.55		0.07		
Post New Long Term	2009	Passenger Car	JC08	g/km	1.15	0.05	0.05	0.05	-
		Mini Commercial Vehicle			4.02				
		Light Commercial Vehicle (GVW ≤ 1.7 t)			1.15				
		Medium Commercial Vehicle (1.7 t < GVW ≤ 3.5 t)			2.55		0.07	0.07	

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Emission standards - gasoline and LPG (cont.)

			Test mode	Unit	CO	NMHC	NOx	PM ^a	PN ^b
2018 regulations	2018	Passenger Car	WLTP ^c	g/km	1.15	0.10	0.05	0.005 (0.007)	-
	2019	Mini Commercial Vehicle			4.02				
		Light Commercial Vehicle (GVW ≤ 1.7 t)			1.15				
		Medium Commercial Vehicle (1.7 t < GVW ≤ 3.5 t)			2.55	0.15	0.07	0.007 (0.009)	-
2024 PN regulation	2024	All the categories	WLTP ^c	#/km	Same as 2018 regulations				6x10 ¹¹

^a PM limit applied for stoichiometric direct injection gasoline engines. Effective from December 2020 for new vehicles and November 2022 for existing vehicles.

Number in brackets is upper limit value.

^b PN limit applied for gasoline direct injection engine only.

^c WLTP Level 1B (UNR 154).

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JAPAN

Emission standards – diesel

			Test mode	Unit	CO	NMHC ^a	NOx	PM	PN	
New Short Term	2002	Passenger Car (VW ≤ 1,265 kg)	10–15 Mode	g/km	0.63	0.12	0.28	0.052	-	
		Passenger Car (VW > 1,265 kg)					0.30	0.056		
		Light Commercial Vehicle (GVW ≤ 1.7 t)					0.28	0.052		
	2003	Medium Commercial Vehicle (1.7 t < GVW ≤ 3.5 t)					0.49	0.06		
New Long Term	2005	Passenger Car (VW ≤ 1,265 kg)	JC08			0.024	0.14	0.013		
		Passenger Car (VW > 1,265 kg)					0.15	0.014		
		Light Commercial Vehicle (GVW ≤ 1.7 t)					0.14	0.013		
		Medium Commercial Vehicle (1.7 t < GVW ≤ 3.5 t)					0.25	0.015		
Post New Long Term	2009	Passenger Car					0.08	0.005		
		Light Commercial Vehicle (GVW ≤ 1.7 t)					0.08	0.005		
		Medium Commercial Vehicle (1.7 t < GVW ≤ 3.5 t)					0.15	0.007		
2018 regulations	2018	Passenger Car					WLTP ^b	0.15		0.005
		Light Commercial Vehicle (GVW ≤ 1.7 t)						0.15		0.005
	2019	Medium Commercial Vehicle (1.7 t < GVW ≤ 3.5 t)						0.24		0.007
2023 PN regulation	2023	All the categories	WLTP ^b	#/km	Same as 2018 regulations			6x10 ¹¹		

^a HC used for New Short Term.^b WLTP Level 1B (UNR 154).

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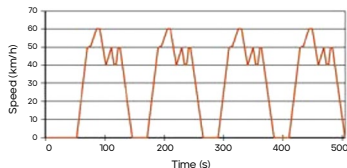
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Driving cycles

11 Mode cold cycle

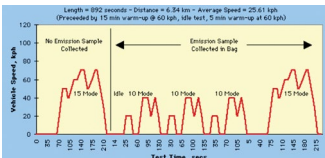
Japan 11 mode



Distance: 4.084 km
Duration: 480 s
Max. speed: 60 km/h
Average speed: 30.6 km/h

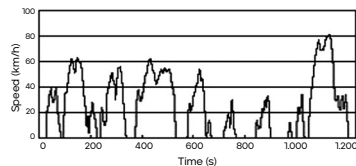
10-15 Mode cold cycle

Japan 10-15 Exhaust Emission & Fuel Economy Driving Schedule



Distance: 6.34 km Duration: 892 s
Average speed: 25.61 km/h
(Preceded by 15 min. warm-up at 60 km/h, idle test, 5 min. warm-up at 60 km/h)
Emissions are measured during the last 4 segments:
Distance: 4.16 km Max. speed: 70 km/h
Duration: 660 s Avg. speed: 22.7 km/h

Driving cycle JC 08



Distance: 8.2 km
Duration: 1,205 s
Max. speed: 80 km/h
Average speed: 24.4 km/h



SOUTH KOREA

Vehicle categories

(Updated based on 2023 Environmental Certification Guidelines)

- Mini-car: Engine displacement < 1,000 cc
- Passenger Car: Engine $\geq 1,000$ cc, GVW < 3.5 t, up to 10 seats
- Medium Passenger Vehicle: GVW ≥ 3.5 t or ≥ 11 seats
- Light Commercial Vehicle: GVW < 3.5 t, ≤ 10 seats
- Medium Commercial Vehicle: $3.5 \text{ t} \leq \text{GVW} < 15 \text{ t}$
- Heavy-Duty Vehicle (HDV): GVW $\geq 15 \text{ t}$
- ZEV (Zero Emission Vehicle): Certified battery electric (BEV) or fuel cell (FCEV) vehicles under separate Ministry of Environment rules

Regulatory background

Korea applies either EU-based or US/CARB-based emission standards, depending on application.

- Gasoline Vehicles: Since 2009, Korea has adopted the CARB NMOG+NO_x Fleet Average System (FAS) for gasoline-fueled LDVs. Automakers must meet fleet-average NMOG+NO_x targets using a range of certified vehicle categories: LEV, ULEV, SULEV, ZEV
- Diesel Vehicles: Since 2014, Korea applies Euro 6 standards, with Euro 6d fully implemented from 2021
- Real Driving Emissions (RDE) and Enhanced Test Cycles: Since 2021, RDE and additional cycles like US06 / SC03 have been more widely applied for compliance evaluation
- ZEV Classification: Battery electric vehicles (BEV) and hydrogen fuel cell vehicles (FCEV) are classified under ZEV and must meet separate certification requirements under Korea's Green Vehicle Promotion Act



SOUTH KOREA

Gasoline fueled vehicles – K-LEV III equivalent to US LEV III, (2016–present)

Category	Durability (km)	Exhaust emissions (g/km)			Notes
		NMOG + NOx ^{f,a,b}	CO ^{f,a,b}	PM	
Standard 1 (LEV160)	15y / 240k	0.100 / 0.087 / 0.062	2.61 / 5.97 / 2.0	0.002 / 0.006 ^c	Cold CO 6.3 g/km ^d
Standard 2 (ULEV125)		0.078 / 0.075 / 0.044	1.31 / 5.97 / 2.0		
Standard 13 (ULEV70)		0.044 / 0.075 / 0.044	1.06 / 5.97 / 2.0		
Standard 4 (ULEV50)		0.031 / 0.075 / 0.044	1.06 / 5.97 / 2.0		
Standard 5 (SULEV30)		0.019 / 0.03 / 0.01	0.625 / 5.97 / 2.0		
Standard 6 (SULEV20)		0.0125 / 0.03 / 0.01	0.625 / 5.97 / 2.0		
Standard 7 (ZEV) ^e		0 ^f	0 ^f	–	Applies to BEV & FCEV

^a For US06 mode.

^b For SC03 mode.

^c PM values: 0.002 g/km (CVS-75 mode), 0.006 g/km (US06).

^d Cold CO limit (–6.7°C): 6.3 g/km (CVS-75 mode).

^e ZEV: Zero Emission Vehicle category defined by Korea's Green Vehicle.

^f For CVS-75 mode.

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SOUTH KOREA

KLEV-III Phase-in and fleet average system

		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Phase-in for EVAP	%	0	0	30	30	80	80	100	100	100	100
Phase-in for PM	%	0	10	20	40	70	100	100	100	100	100
FTP FAS	NMOG+NO _x (g/km)	0.063	0.058	0.053	0.048	0.043	0.039	0.034	0.029	0.024	0.019
SFTP FAS ^a	CO (g/km)	0.069	0.064	0.061	0.056	0.052	0.048	0.044	0.039	0.036	0.031
		2.61									

^a Manufacturer self select SFTP standards for each vehicle family.

Exhaust emissions standards for diesel fueled vehicles

Light-duty vehicles	Euro 5b	Euro 6b	Euro 6c	Euro 6d-temp ^a	Euro 6d ^b
NT	1 Sep 2011	1 Sep 2014		1 Oct 2017	1 Jan 2020
NV	1 Sep 2023	1 Sep 2015	1 Sep 2018	1 Sep 2015	1 Jan 2021

^a WLTC mode and RDE NO_x + PN. ^b Enforced RDE NO_x + PN.

2026 and beyond:

- As of 2025, there is no official announcement from the Korean Ministry of Environment regarding updated NMOG+NO_x or CO targets for 2026 or 2027
- Korea is monitoring EU Euro 7 regulations but has not declared any adoption schedule
- Future regulations may reflect global trends such as Euro 7 or US EPA Tier 4, as well as a stronger emphasis on Real Driving Emissions (RDE)

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BRAZIL - PROCONVE L8 STANDARDS

Overview and standards

- Implementing date: January 2025

PROCONVE L8 fleet average NMOG + NOx limits (mg/km)

Implementation Date	Passenger Cars	Commercial Vehicles
1 January 2025	50	140
1 January 2027	40	110
1 January 2029	30	50
1 January 2031	30	30

- Several parameters equivalent to PROCONVE L7:
 - Cycles: FTP75
 - Durability: 160,000 km / 10 years
 - Fuels
 - Smoke index in free acceleration for Diesel vehicles
 - Periodic regeneration - K_i factor
- Auxiliary emissions control device (AECD) declaration required for all vehicles. Emissions increasing (EI) AECD required for CI vehicles. Alternative option is AES/BES documentation (based on EU)

^a Only spark-ignited direct injection or diesel engines.

^b Only diesel engines with SCR using urea.

^c Only PI.

^d ME = Test mass.

Available emission levels (mg/km)

	Level	NMOG+NOx	PM ^a	CO	Aldehydes ^c	NH ₃ ^b (ppm)
Diesel LCV	320	320	20	1,000	-	10
	280	280	20	1,000	-	
	250	250	20	1,000	-	
	220	220	10	1,000	-	
	200	200	10	1,000	-	
	170	170	9	1,000	-	
SI LCV and diesel LCV above 1,700 kg ME ^d	140	140	6	1,000	15	
	110	110	6	1,000	15	
Light Passenger and Light Commercial Vehicles up to 1,700 kg ME ^d	80	80	6	1,000	15	
	70	70	4	600	10	
	60	60	4	600	10	
	50	50	4	600	10	
	40	40	4	500	10	
	30	30	3	500	8	
	20	20	2	400	8	
	0	null	null	null	null	null

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BRAZIL - PROCONVE L8 STANDARDS

Real driving emissions (RDE)

RDE testing started with PROCONVE L7 with a monitoring phase.

The testing is largely inspired by UNR168 but with some Brazilian adaptations:

With PROCONVE L8, NMHC + NO_x emissions requirements appeared:

Application date	Pollutants	CF
January 2025	NMHC + NO _x	2
January 2027	NMHC + NO _x	1.5

- Trip composition: 65% Urban / 35% Rural
- Maximum Speed: 110 km/h
- Temperature range:
 - Standard → $15^{\circ}\text{C} \leq T_{\text{air}} \leq 35^{\circ}\text{C}$
 - Extended → $10^{\circ}\text{C} \leq T_{\text{air}} < 15^{\circ}\text{C} - 35^{\circ}\text{C} < T_{\text{air}} \leq 40^{\circ}\text{C}$
- Reference CO₂ from FTP:
 - P1=phase 2 FTP / P2 = phase 3 FTP / P3 = P2

All other parameters are equivalent to Europe (Evaluation method, extended factor, altitude, Stop time, Final correction...) – See Europe section (pages 24 to 30).



BRAZIL - PREVIOUS STANDARDS

PROCONVE L5 and L6 standards

Implementation dates:

- PROCONVE L5: MY 2009 onwards
- PROCONVE L6: MY 2014 onwards

Relevant parameters (from CY 2002):

- Fixed deterioration factors for annual production < 15,000 vehicles:
CO and HC 1.2. NOx 1.1
- Unburned ethanol is not allowed to be deducted from hydrocarbon emission results
- FTP-75 cycle / Highway cycle test (E22 and E100 fuels only – ABNT NBR 7024)
- Fuels:
 - Certification required with E22 fuel for E22 vehicles
 - Certification required with E22 / E60 / E100 and CNG for a tri-fuel vehicle

L5 and L6 emissions limits on FTP

Vehicle	Standard (g/km)	NMHC	CO	NOx ^a	Aldehydes ^c	PM ^b
PC	L5	0.05	2.0	0.12 (0.25)	0.02	0.050
	L6		1.3	0.08	0.02	0.025
LCV ≤ 1,700 kg	L5	0.05	2.0	0.12 (0.25)	0.02	0.050
	L6		1.3	0.08	0.02	0.030
LCV > 1,700 kg	L5	0.06	2.7	0.25 (0.43)	0.04	0.060
	L6		2.0	0.25 (0.35)	0.03	0.040

- Durability 80,000 km / 5 years
- Total HC only for natural gas powered vehicles: 0.3 g/km for PC/LCV ≤ 1,700 kg, 0.5 g/km for LCV > 1,700 kg
- CO at idle speed for gasoline: 0.2% in volume

^a Diesel limits in brackets.

^b PM only for diesel engines.

^c Aldehyde limits only for Otto-Cycle vehicles.

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BRAZIL - PREVIOUS STANDARDS

PROCONVE L7 Standards

- Implementation date: January 2022
- FTP-75 cycle (ABNT NBR 12.026:2016, ABNT NBR 15598:2016, ABNT NBR 6.601:2012, ABNT NBR 16.567:2016)
- Highway cycle test (E22 and E100 fuels only - ABNT NBR 7024)
- RDE monitoring
- Durability 160,000 km / 10 years

Deterioration factors should be determined through vehicle mileage accumulation testing. Alternatively, for annual production < 15,000 vehicles, assigned DF could be used:

Engine type	Multiplicative factor for exhaust emissions				
	NMHC	CO	NOx	Aldehydes	PM
Diesel	1.2	1.2	1.2	1.0	1.2
Otto	1.4	1.4	1.2	1.2	1.0

- Smoke index in free acceleration for Diesel vehicles: 0.4 m⁻¹ up to 2,000 m

Emissions limits on FTP

Vehicle	NMOG+NOx (mg/km)	PM ^a (mg/km)	CO (mg/km)	Aldehydes ^c (mg/km)	NH ₃ ^b (ppm)
PC	80	6	1,000	15	To be declared
LCV ≤ 1,700 kg	140 ^c	6 ^c			
LCV > 1,700 kg	320 ^d	20 ^d		-	

^a Only spark-ignited direct injection or diesel engines. ^b Only diesel engines with SCR using urea. ^c Only spark-ignited engines. ^d Only diesel engines.

- Certification fuels:
 - E22 for E22 vehicles
 - E22 / E60 / E100 and CNG for tri-fuel vehicles
- Regenerative emission control devices (see EU section):
 - Periodic regeneration process at less than 4,000 km of vehicle operation: K_i factor is necessary
 - Determine according to UN ECE R83 Rev5 (EU - before Euro 6c)
 - Additive or multiplicative coefficient

OTHER AREAS OF THE WORLD - EMISSIONS REQUIREMENT

Argentina	Since 2018, for ALL vehicles: Euro 5a
Australia	Current legislation: Euro 5a Starting December 2025: Euro 6d
Canada	Starting MY 2017, harmonization with the emission standards of the US EPA Tier 3 program
Chile	Vehicle emissions standards in Chile are based on EU standards; options to use US EPA standards are also in place: • Current legislation: EU standard: Euro 6b / US standard: Tier 3 bin 125 • From October 2025: EU standard: Euro 6c / US standard: Tier 3 bin 70
Hong Kong	California LEV III standards apply for new diesel passenger cars since 1 October 2017; Euro 6c standards apply to new gasoline passenger cars from 1 September 2019
Indonesia	From April 2022, requirements for all new diesel duty vehicles is to comply with Euro 4
Mexico	Current legislation: either Tier 2 or Euro 4

Morocco	Current legislation: for all vehicles from July 2024, Euro 6b
New Zealand	Current options: • Gasoline Euro 5 or US Tier 2 or Japan 2005 or Japan 2018 or ADR^a 79/04 • Diesel Euro 5 or US Tier 2 or Japan 09 or ADR 79/04 Next step options (1 Dec 2025 for NT, 1 July 2028 for NV): • Gasoline Euro 6d or US Tier 3 or Japan 2018 or UNR83/08 or ADR 79/05 • Diesel Euro 6d or US Tier 3 or Japan 2018 or UNR83/08 or ADR 79/05
Peru	Peru applies EU emissions requirements and options are also given to comply with US Federal standards. Current legislation: Euro 4 / US EPA Tier 2 Bin 5. From October 2025: Euro 6b or more stringent (US Tier3 bin 125)
Philippines	Current legislation: Since January 2016, Euro 4
Russia	Current legislation: Starting January 2013, Euro 5a
Saudi-Arabia	Current legislation: • Gasoline vehicles: Euro 4 • Diesel vehicles: Euro 5b

^a Australian Design Rule

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OTHER AREAS OF THE WORLD - EMISSIONS REQUIREMENT

Singapore	Current legislation: Euro 6d Options to certify vehicles to standards based on Japan 2009 or Japan 2018 requirements are also in place (with some conditions: PN / WLTC cycle)
South Africa	Current legislation: Euro 2 Implementation of Euro 5 delayed
Switzerland	Has national requirements harmonized to EU requirements
Taiwan	Current legislation: from September 2019, Euro 6d-temp. (US EPA Tier 3 as an option)
Thailand	Current legislation, from January 2025: • SI engines: Euro 6 • Diesel vehicles: Euro 5
Turkey	Current legislation: Euro 6
UK	Current legislation: Euro 6d (UNR154 / UNR168)

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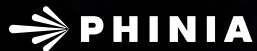
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TAKE TODAY IMPACT THE WORLD
WE HAVE TOMORROW. THAT'S WHY
WE'RE MOVING TOWARDS GREATER
SUSTAINABILITY, IMPROVING RESOURCES,
AND EXPLORING INVESTMENTS FOR A
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EUROPEAN UNION - CO₂ EMISSION STANDARDS GENERAL PROVISIONS

EU regulation on CO₂ emission reduction for passenger car (M₁) and light commercial vehicles (N₁)

Regulation (EC) No. 443/2009 set standards for average specific emissions of CO₂ for each manufacturer for new passenger cars (PC) registered in the EU in each calendar year for 2015 to 2019, and 2020 onwards. (EC) No. 510/2011 set the same for light commercial vehicles (LCV) (starting in 2017).

Regulation (EU) 2019/631 set new annual standards for both passenger cars and light commercial vehicles for 2025 to 2029 and 2030 onwards.

In 2023, Regulation (EU) 2019/631 was amended to tighten the 2025 and 2030 standards for passenger cars and light commercial vehicles and set zero CO₂ targets for 2035.

Timeline of CO₂ standards according to relevant test cycles

	Passenger cars		Light commercial vehicles	
	NEDC ^a	WLTP ^b	NEDC	WLTP
2015	130 g/km		175 g/km (2017)	
2020 ^c	95 g/km	→ equivalent ^e	147 g/km	→ equivalent ^e
2025 ^d		-15%		-15%
2030		-55%		-51%
2035		-100%		-100%

^aNew European Driving Cycle.

^bWorld Light-duty Test Procedure.

^cPhased in, applicable to 95% of fleet in 2020, 100% in 2021.

^dCompliance permitted over 2025-2027 period instead of individual years.

^eNEDC target converted to WLTP.

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EUROPEAN UNION - CO₂ EMISSION STANDARDS GENERAL PROVISIONS

CO₂ emission limit curves to calculate manufacturer targets

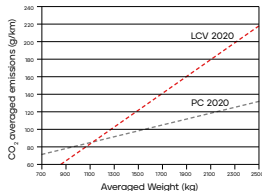
The CO₂ emission annual target varies as a function of the vehicle mass. CO₂ target vs. mass curves for each manufacturer are defined by the following formula:

$$\text{CO}_2 = \text{Target} + a \times (M - M_0)$$

Where:

- Target = fleetwide CO₂ target for all vehicles sold
- a = slope of the CO₂ vs. mass curve^a
- M_0 is the European fleet averaged mass of previous years (see table)
- M is the average mass of the manufacturer's vehicles in the year in question

CO₂ emission limit curves for Passenger Cars and Light Commercial Vehicles, showing the example of 2020.



Parameters for target curves

The parameters for the target curves until 2025 are set out in the table below.

Vehicle type	Years	Target g/km (WLTP)	a	$M_0 / TM_0(2025)$	M_0 / TM_0 averaging basis years
			g/km / kg	kg	
Passenger Cars	2020-2021	110.1	0.0333	1,379.88	2014 - 2016
	2022-2024	110.1		1,455.69	2017 - 2019
	2025	93.6	-0.0144 ^b	1,650.15	2021 - 2023
Light Commercial Vehicles	2020	147 ^c (181.1)	0.096	1,766.40	2016
	2021-2023	181.1		1,825.23	2018
	2024	181.1		1,875.07	2019 - 2021
	2025	153.9	0.0848 / 0.1064 ^d	2,161.13	2022 - 2023

^a Target line slope equal to 60% of the slope of the best fit straight line of CO₂ vs. mass of all vehicles in the fleet.

^b Note negative slope of 2025 curve, due to effect of high-mass low-emission plug-in hybrids.

^c Target level refers to the NEDC emission test procedure, with conversion to WLTP in brackets.

^d For vehicles less than / greater than TM_0 respectively.

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EUROPEAN UNION - STANDARDS FOR 2021-2024

CO₂ fleet target 2021 to 2024 adapted to WLTP from NEDC

The WLTP test procedure was introduced in September 2017 to replace the NEDC. From 2017 to 2020, the CO₂MPASS correlation tool was used to transpose CO₂ emissions measured on WLTC into the NEDC values applied to calculate manufacturers' performance in comparison to the original NEDC CO₂ targets. In 2020, the CO₂ emissions of all new vehicles were determined with both NEDC and WLTP, to enable the conversion to the specific WLTP emission target for 2021.

Starting 2021, manufacturers had individual CO₂ reference targets based and measured on WLTP adapted to 14°C, converted from NEDC.

The reference target is calculated from the manufacturer's target fulfillment obtained in 2020 based on NEDC, and from its CO₂ performance obtained in 2020 on WLTP, as follows:

$$WLTP_{reference.target} = WLTP_{2020.CO_2} \cdot \left(\frac{NEDC_{2020.target}}{NEDC_{2020.CO_2}} \right)$$

Where:

- $WLTP_{2020.CO_2}$ is the averaged CO₂ emissions in 2020 obtained on WLTP

- $NEDC_{2020}$ target is the 2020 fleet specific emission target of the OEM
- $NEDC_{2020.CO_2}$ is the averaged CO₂ emissions in 2020 calculated on NEDC

The specific WLTP emission target for each manufacturer is calculated according to their average mass, correcting for the average mass in 2020, as follows:

$$\text{Specific emission target} = WLTP_{reference.target} + a [(M_b - M_0) - (M_{b,2020} - M_{0,2020})]$$

Where:

- a is the coefficient defined for the year 2020 in table on previous page
- M_0 is the reference mass for the specific calendar year, for 2021 it is the same as 2020
- M_b is the manufacturer's averaged mass in the specific calendar year
- $M_{0,2020}$ is the reference mass for 2020 defined in table on previous page
- $M_{b,2020}$ is the manufacturer's averaged mass registered in 2020



EUROPEAN UNION - STANDARDS FOR 2025-2029 AND 2030-2034

Calculation of 2021 CO₂ reference value

As a basis for calculating targets for 2025 and subsequent years, a CO₂ reference value for 2021 is calculated for each OEM, as follows:

$$\text{Reference value}_{2021(i)} = \text{WLTP}_{2020_CO_2_measured} \cdot \left(\frac{\text{NEDC}_{2020 \text{ fleet target}}}{\text{NEDC}_{2020_CO_2}} \right) + \alpha \cdot (M_{0,2021} - M_{0,2021})$$

Where:

- WLTP_{2020_CO2_measured} is the manufacturer's averaged CO₂ emission in 2020
- NEDC₂₀₂₀ is the fleet target (95 g CO₂/km for PC; 147 g CO₂/km for LCV)
- α is the coefficient 0.0333 for PC; 0.096 for LCV
- M_{0,2021} is the manufacturer's averaged mass in running order registered in 2021
- M_{0,2021} is the averaged mass in running order of all new vehicles registered in 2021
- Reference values for 2021 are 110.1 g/km for PC and 181.1 g/km for LCV

Fleet-wide CO₂ target

From 2025 a unique WLTP EU target is defined for the fleet of all vehicles sold, based on the weighted average of the OEM reference values for 2021, and applying the reduction factors for 2025 and 2030, as follows:

$$\text{EU Fleet wide target}_{2025/2030} = \left(\frac{\sum \text{Reference value}_{2021(i)} \cdot N(i)}{\sum N(i)} \right) \cdot (1 - \text{reduction factor}_{02025/2030})$$

Where:

- N(i) is the number of vehicles sold by OEM (i) in 2021
- Reduction factor = reduction in CO₂ target compared to 2020 target
- Reduction factor₂₀₂₅ = 0.15 (15% reduction)
- Reduction factor₂₀₃₀ = 0.55 for PC (55% reduction); 0.51 for LCV (51% reduction)



EUROPEAN UNION - STANDARDS FOR 2025-2029 AND 2030-2034

Calculation of manufacturers' individual CO₂ targets

From 2025 the 'specific emissions reference target' of each OEM is calculated by adjusting the fleet-wide target by the weight-based limit curve as follows:

Specific emissions reference target_{2025/2030} = EU Fleet wide target_{2025/2030} + $\alpha_{2025/2030} \cdot (TM - TM_0)$

Where:

- TM is the manufacturer's averaged test mass of vehicles sold in the calendar year
- TM₀ is the EU averaged test mass of all vehicles registered in the calendar year
- The weight coefficient for 2025 or 2030 $\alpha_{2025/2030}$ is adapted from the 2021 value:

$$\alpha_{2025/2030} = \alpha_{2021} \cdot \left(\frac{\text{EU Fleet wide target}_{2025/2030}}{\text{Average emissions}_{2021}} \right)$$

Where:

- α_{2021} is the slope of CO₂ emissions versus test mass of all vehicles registered in 2021 in the EU

Calculation of manufacturers' individual CO₂ targets adjusted for ZLEV factor

From 2025, each OEM's specific emissions target can be increased (made less stringent) by the 'ZLEV factor' if the share of zero and low-emission vehicles is above a set threshold.

Specific emissions target_{2025/2030} = Specific emissions reference target_{2025/2030} · ZLEV Factor

The ZLEV factor = $1 + \gamma - x$, where:

- γ = the weighted share of low and zero emissions vehicles in the manufacturer's fleet (< 50 g CO₂/km), in which each ZLEV is given a weight known as:

$$\text{ZLEV specific} = 1 - \frac{\text{Specific emissions of CO}_2}{50}$$

- x is the benchmark for low and zero emission vehicles:
 - x = 25% for PC and 17% for LCV for the years 2025 to 2029
 - Maximum value 1.05
 - Minimum value 1.0



EUROPEAN UNION - STANDARDS FOR 2025-2029 AND 2030-2034

Modalities for applying the CO₂ fleet average targets

Each manufacturer has an individual target based on the calculations detailed on the previous page. Manufacturers submit fleet data after the end of each the year to the European Commission for verification.

1. Eco-innovation credit

Eco-innovations are technologies that reduce CO₂ emissions whose effects are not captured in the test cycle CO₂ measurement. Proposed eco-innovations are submitted to the European Commission for approval. When installed in vehicles, the technology gains a CO₂ credit that must be greater than 1 g/km CO₂ per innovation. The maximum permitted contribution of eco-innovations is:

- 7 g CO₂/km per year until 2024
- 6 g CO₂/km per year from 2025 until 2029
- 4 g CO₂/km per year from 2030 until 2034

2. Excess emission premiums

If the manufacturer's averaged CO₂ is above its specific target, an excess emissions premium (penalty) applies. The annual premium is €95 per g/km above the manufacturer's individual target multiplied by the number of vehicles sold during the year by the manufacturer.

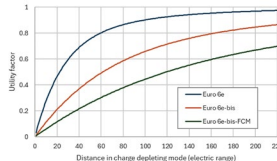
3. Plug-in hybrids

The CO₂ emissions of plug-in hybrids (PHEVs) are determined from the CO₂ measured using the ICE with the electric motor switched off (charge sustaining mode) according to a 'utility factor' dependent on their electric range (distance in charge-depleting mode). The CO₂ value is calculated as:

$$\text{PHEV CO}_2 \text{ value} = \text{CO}_2 \text{ measured in charge sustaining mode} \times (1 - \text{UF})$$

The calculation of the utility factor is being adapted according to real-world data and will be reduced in two steps from 2025 to 2027 when new Euro 6 stages are implemented, see chart.

4. Utility factor vs. electric range



Example values

	UF (100)	CO ₂ g/km
Euro 6e to 2024	0.9	12
Euro 6e-bis (from 2025)	0.66	42
Euro 6e-bis-FCM (from 2027)	0.44	68



EUROPEAN UNION - STANDARDS FOR 2025-2029 AND 2030-2034

Amendments to CO₂ fleet targets 2025 to 2029

In June 2025, Regulation (EU) 2025/1214 was adopted amending Regulation 2019/631 regarding the enforcement of the targets from 2025 to 2027.

The amendment allows OEMs to average out their emissions over the three-year period from 2025 to 2027, instead of being required to meet the 2025-2029 target in each individual year.

In practice this amendment allows OEMs to have a CO₂ value higher than the target in one or two of the three years, as long as it is compensated by an equivalent over-performance in the other one or two years.

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US - CO₂ AND CAFE STANDARDS

The US has 2 sets of parallel standards:

1. CAFE – Corporate average standards adopted by NHTSA
2. Greenhouse Gas (GHG) standards based on CO₂ under EPA

History

- CAFE standards were first adopted in 1975 and nearly doubled fleet average fuel economy by 1985. CAFE standards remained in force but targets remained steady through 2010
- The Energy Independence and Security Act (EISA) was passed in 2007, mandating a 40% increase in fuel economy in the following decades. In a parallel development in 2007, the US Supreme Court ruled CO₂ as a pollutant under the Clean Air Act (CAA), leading to the 2009 "Endangerment finding" enabling CO₂ emissions from mobile sources to be regulated under the CAA
- Under CAFE, manufacturers can pay penalties in lieu of meeting standards. Under the CAA, civil penalties apply for manufacturers not complying with GHG standards, significantly higher than the CAFE penalties, with the potential for more severe sanctions
- In April 2010, EPA and NHTSA finalized new harmonized CAFE and GHG Rules for MY 2012-2016 light-duty vehicles

- In August 2012, EPA and NHTSA issued joint final rules extending the harmonized GHG and CAFE standards for MY 2017-2025
- On 31 March 2020, the US EPA and NHTSA issued the SAFE Final Rule Part 2 that modified CAFE and CO₂ standards setting an improvement rate of 1½% per annum from MY 2020 basis applied to MY 2021 to MY 2026
- On 30 December 2021, the EPA published revisions to the light-duty GHG emission standards for MY 2023 through MY 2026, making the GHG standards more stringent than under the previous SAFE rule
- On 20 March 2024, the EPA published further revisions to the light-duty GHG emission standards for MY 2027 through MY 2032, continuing the downward trajectory of the targets

Recent developments

- In July 2025, the EPA issued a proposal to reverse the 2009 Endangerment Finding and roll back the CO₂ standards for light and heavy-duty vehicles. A final decision is due later in 2025
- CAFE: in July 2025, the One Big Beautiful Bill was signed into law, including a provision that eliminates CAFE penalties from MY 2022

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US - CO₂ AND CAFE STANDARDS

2017-2025 standards (SAFE rule)

Standards are based on CO₂ emissions-footprint curves, where each vehicle has a different fuel economy and CO₂ emissions compliance target depending on its 'footprint' value, related to track and wheelbase of the vehicle. The table on the next page provides estimated final requirements provided in the SAFE Rule release.

1. CH₄ and N₂O Standards

In addition to the fleet-average CO emission targets, the rule also includes emission caps for tailpipe N₂O and methane emissions (FTP-75). These were unchanged in the SAFE rule.

- N₂O: 0.010 g/mile - CH₄: 0.030 g/mile

2. Flexibilities

The regulation also includes a system of Averaging, Banking and Trading (ABT) of credits, based on a manufacturer's fleet average CO₂ performance. Credit trading is allowed between vehicle types and between companies.

The rule includes credits^a for:

- Advanced technology vehicles

- Reduced leakage from AC refrigerant
- Improved AC efficiency
- Off-cycle CO₂ reducing technologies
- Qualifying full-size light pickup trucks (that deploy mild or full hybrid systems to fleet percentage targets or better than targets by 15-20%)

3. Revision

In 2021, EPA adopted revised GHG standards^b tightening the CO₂ targets for MY 2023+ (see table).

Multipollutant rule

On 20 March 2024, the EPA issued the 'Multipollutant rule' that set fleet average CO₂ standards for cars and light trucks from 2026 to 2032 (see table).

According to the regulatory impact analysis, compliance with the rule is projected to require increasing shares of zero-emission vehicles, reaching 56% in 2032 for the combined car and light truck fleet.

^a See 40 CFR 86.1866.12 - 86.1871.12 and 49 CFR 531.6 for details.

^b Federal Register Pages 74434-74526 Published 30 December 2021.

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US - CO₂ AND CAFE STANDARDS

2017-2032 overview of standards - average of OEMs' CAFE and CO₂ Estimated Final Requirements^a

Vehicle category & standard by model year		SAFE rule						Revised CO ₂ rule				Multipollutant rule						
		2017	2018	2019	2020	2021	2022 ^b	2023	2024	2025	2026	2026	2027	2028	2029	2030	2031	2032
Passenger Cars	CO ₂ g/mi	219	208	197	188	183	180	181	166	158	149	131	139	125	112	99	86	73
	CAFE (mpg)	39	40.4	41.9	43.6	44.2	44.9	45.6	46.3	47.0	47.7	-	60.0	61.2	62.5	63.7	65.1	66.4
Light-Duty Trucks	CO ₂ g/mi	295	285	278	270	264	259	234	222	207	187	184	184	165	146	128	109	90
	CAFE (mpg)	29.4	30	30.5	31.1	31.6	32.1	32.6	33.1	33.6	34.1	-	42.6	42.6	43.5	44.3	45.2	46.2
Combined Cars & Truck Fleet	CO ₂ g/mi	255	244	235	226	220	216	202	192	179	161	168	170	153	136	119	102	85
	CAFE (mpg)	33.8	34.8	35.7	36.8	37.3	37.9	38.5	39.1	39.8	40.4	-	47.3	47.4	48.4	49.4	50.4	51.4
YOY ^c reduction (CO ₂)		-	4.3%	3.7%	3.8%	2.7%	1.8%	6.5%	5.0%	6.8%	10.1%	- ^d	- ^d	10%	11.1%	12.5%	14.3%	16.7%

^a Projected fuel economy required before credits and incentives.

^b SAFE Rule Reference Value.

^c Year over Year CO₂ Reduction for Combined Fleet.

^d No increase vs. previous year.

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CALIFORNIA - ZERO-EMISSION VEHICLE MANDATE

History

- The federal Clean Air Act allows the California Air Resources Board (CARB) to adopt more stringent emissions rules, including ZEV mandates, than federal rules if the EPA grants an authorizing waiver
- Other states may elect to follow California rules instead of federal. These are known as Section 177 states
- The following provides a historical timeline:
 - 1990: the first ZEV mandate was adopted requiring 2% of sales to be ZEV in 1998 rising to 10% in 2003
 - 1998: the 'ramp-up' years were eliminated with the 2003 10% target retained
 - 2002: a lawsuit prevented CARB from enforcing the ZEV mandate in 2003 and 2004
 - 2004: a new rule set targets from 2005 to 2018 with a credit multiplier scheme that enabled manufacturers to meet targets partially with non-ZEV vehicles
 - 2009: the targets from 2009 onwards were suspended
 - 2012: CARB adopted the Advanced Clean Cars program (ACC), setting ZEV mandate and GHG targets (aligned to federal GHG) from 2018 to 2025
 - 2019: EPA issued the SAFE rule weakening federal CO₂ standards from 2021 onwards, and withdrew CARB's ACC waiver, revoking its ability to implement its ZEV mandate
 - 2021: EPA reinstated CARB's waiver for ACC
 - 2022: CARB adopted the Advanced Clean Cars II (ACC II) program, setting ZEV mandate targets from 2026 to 2035
 - 2025: the US Congress passed a resolution, signed by the President, revoking the California waivers for ACC II, preventing it from entering into force and "substantially the same" rules being implemented in future
- As of 2025, 15 Section 177 states plus California, representing almost 40% of the market, were implementing the ACC ZEV mandate
- CARB intends to continue enforcement of ACC, with the MY 2025 ZEV target of 22% in force for MYs 2026 onwards, which is however disputed by EPA

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CALIFORNIA - ZERO-EMISSION VEHICLE MANDATE

Advanced Clean Cars (ACC) - ZEV mandate from 2018-2025

In 2012, CARB adopted the Advanced Clean Cars program including updated ZEV targets for model years 2018 to 2025 (see table), with a credit-based system.

Each vehicle manufacturer obtains either ZEV credits to meet a minimum ZEV floor percentage or 'transitional' ZEV (TZEV) to meet the remaining requirement.

Model year	2018	2019	2020	2021	2022	2023	2024	2025+
General percentage ZEV requirement	4.5%	7.0%	9.5%	12.0%	14.5%	17.0%	19.5%	22.0%
Minimum ZEV floor	2%	4%	6%	8%	10%	12%	14%	16%
Maximum TZEV option	2.5%	3%	3.5%	4%	4.5%	5%	5.5%	6%



CALIFORNIA - ZERO-EMISSION VEHICLE MANDATE

ACC: Definitions of ZEV types and the credits available for each

Acronym	Eligible vehicle types	Can fulfill obligation	(Equivalent) All Electric Range ((E)AER) ^b	ZEV credits
ZEV ^a	Battery electric vehicle Fuel cell electric vehicle	ZEV	< 50 Miles	0
			50 mi ≤ AER ≤ 350 mi	0.5+0.01 x AER
			> 350 miles	4
NEV ^c	ZEV low-speed vehicles	ZEV	N/A	0.15
BEVx	Range-extended electric vehicle	ZEV	< 75 Miles	0
			75 mi ≤ AER ≤ 350 mi	0.5+0.01 x AER
			> 350 miles	4
TZEV	Plug-in hybrid	TZEV	< 10 Miles	0
			10 mi ≤ EAER ≤ 80 mi	0.3+0.01 x EAER
			> 80 miles	1.1
H ₂ ICE	Hydrogen Internal Combustion Engine Vehicles > 250 miles	TZEV	AER < 10 Miles	0.75
			10 mi ≤ AER ≤ 20 mi	1.05+0.01 x AER
			20 miles < AER	1.25

^a ZEV = vehicle that produces zero exhaust emissions of any criteria pollutant (or precursor pollutant) or greenhouse gas under any possible operational modes or conditions.

^b All electric range for battery electric vehicles, hydrogen range for hydrogen vehicles, equivalent all electric range for non-ZEVs with zero-emission capability.

^c Neighborhood electric vehicle.

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CALIFORNIA - GREENHOUSE GAS STANDARDS

History

- California led development of regulation to control greenhouse gases (GHG). First passed in 2002, regulations became effective in January 2006 and phased in from 2009-2016
- In 2010, California adopted regulations such that cars that complied to Federal MY 2012-2016 standard would also comply with CARB standards for the same MYs
- In January 2012, California enacted the Advanced Clean Cars rule that included GHG targets for MY 2017 to 2025 vehicles based on vehicle footprint (in addition to LEV III criteria pollutant rules)

The GHG targets were aligned to federal standards (see table) and vehicles meeting federal targets were 'deemed to comply'.

- In 2019, EPA withdrew the ACC waiver preventing California from regulating GHG
- Subsequently, CARB reached a voluntary agreement with several automakers establishing a nationwide target of 3.7% GHG annual reduction from 2022 to 2026 of which 1% can be met with advanced technology multiplier credits
- In 2021, the EPA restored the ACC waiver granting to California the authority to regulate greenhouse gas emissions directly

Projected 2017-2025 fleet-wide CO₂ and fuel economy compliance levels

Vehicle category		Model year								
		2017	2018	2019	2020	2021	2022	2023	2024	2025
Passenger Cars	CO ₂ g/mi	212	202	191	182	172	164	157	150	143
Light-Duty Trucks	CO ₂ g/mi	295	285	277	269	249	237	225	214	203
Combined Cars & Trucks	CO ₂ g/mi	243	232	222	213	199	190	180	171	163

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CALIFORNIA - ZERO-EMISSION VEHICLE MANDATE (REVOKED - NOT IN FORCE)

Advanced Clean Cars II (ACC II) - ZEV mandate from 2026-2035

Due to the Congressional resolution passed under the federal Congressional Review Act, revoking the EPA waiver, ACC II is prevented from being implemented. CARB is appealing the legality of the decision and continues to develop its ZEV program. The following description of ACC II is for reference purposes.

The Advanced Clean Cars II rule was adopted in 2022 (CCR 1962.4, Title 13), implementing ZEV targets for model years 2026 onwards reaching 100% in 2035 (see table).

- Eligible ZEVs must have a certified all-electric range (AER) ≥ 200 miles and meet several other requirements (section (d)(1)). Each vehicle counts as one ZEV for the purposes of this requirement
- PHEVs count as ZEV if they meet several conditions (section (e)(1)(A))
 - A PHEV with AER ≥ 70 miles and US06 ≥ 40 miles may count as one towards the manufacturer's annual ZEV requirement
 - PHEVs with AER ≥ 43 miles and < 70 miles (from MY 2026 - MY 2028 only may count according to the following partial value capped at 0.85:

$$\text{Partial Vehicle Value} = \frac{\text{Verification Range Value}}{100} + 0.20$$

- The manufacturer can claim additional partial ZEV value of 0.15 if US06 AER ≥ 10 miles PHEV
- The total PHEV allowance (contribution of PHEV credits to meeting the ZEV target) can be maximum of 20% of the manufacturer's ZEV annual requirement
- Environmental Justice (EJ) flexibilities giving extra ZEV credit to manufacturers that take action to help increase affordable access to ZEVs for our priority communities

Percentage Requirement for Calculation of Annual ZEV Requirement

Model year	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035+
General percentage ZEV requirement	26%	34%	43%	51%	61%	76%	82%	88%	94%	100%
Of which, maximum PHEV allowance	5.2%	6.8%	8.4%	10.2%	12.2%	13.2%	16.4%	17.6%	18.8%	20%

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PR OF CHINA - FUEL CONSUMPTION STANDARDS FOR PASSENGER CARS

Application of standards

- Passenger car standards apply both to individual vehicle families and to fleet Corporate Average Fuel Consumption (CAFC), evaluated against weight-based fuel consumption (FC) targets
- Vehicle makers with a CAFC above the target face penalties
- The NEV credit system (see page 107) can be used towards the CAFC regulation for passenger cars
- CAFC target calculation:

$$T_{CAFC} = \frac{\sum_{i=1}^N T_i \times V_i}{\sum_{i=1}^N V_i}$$

i = serial number of the vehicle family.

T_i = vehicle fuel consumption target of single family i , which is defined in the table of 'China Fuel Consumption Evaluation Methods and Targets for Passenger Cars, GB 27999, L/100 km'.

V_i = the annual quantity of the single family of vehicle i .

Fuel consumption targets

CAFC may exceed the target (see next page) by a certain percentage each year until the final year (2020 and 2025 for Phase IV and V respectively).

GB 27999-2014 CAFC Phase IV Final CAFC target = 5 L/100 km					GB 27999-2019 CAFC Phase V Final CAFC target = 4 L/100 km				
2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
134%	128%	120%	110%	100%	123%	120%	115%	108%	100%



PR OF CHINA - FUEL CONSUMPTION STANDARDS FOR PASSENGER CARS

Phase V and VI individual and fleet average fuel consumption targets as a function of curb mass (CM)

Phase V introduced CAFC standards from January 2021 and individual vehicle fuel economy standards from July 2021 based on curb mass (CM).

CM (kg)	Targets per vehicle family, Phase V (L/100 km)		CAFC targets, Phase V (L/100 km)	
	Manual transmission	Automatic transmission	Manual transmission	Automatic transmission
$CM \leq 750$	5.82	6.27	4.02	4.22
$750 < CM \leq 1,090$	$0.0041 \times (CM - 1,415) + 8.55$	$0.0042 \times (CM - 1,415) + 9.06$	4.02	4.22
$1,090 < CM \leq 2,510$	$0.0041 \times (CM - 1,415) + 8.55$	$0.0042 \times (CM - 1,415) + 9.06$	$0.0018 \times (CM - 1,415) + 4.6$	$0.0018 \times (CM - 1,415) + 4.8$
$2,510 < CM$	13.04	13.66	6.57	6.77

Phase VI is planned from January 2026 for both CAFC and individual vehicles^a.

CM (kg)	Targets per vehicle family, Phase VI (L/100 km)		CAFC targets, Phase VI (L/100 km)	
	< 3 rows of seats	≥ 3 rows of seats	< 3 rows of seats	≥ 3 rows of seats
$CM \leq 1,090$	5.90	6.31	2.57	2.71
$1,090 < CM \leq 2,510$	$0.0034 \times (CM - 1,580) + 7.57$	$0.0035 \times (CM - 1,580) + 8.02$	$0.0015 \times (CM - 1,580) + 3.3$	$0.0015 \times (CM - 1,580) + 3.46$
$2,510 < CM$	10.73	11.28	4.70	4.84

^a Annual phase-in percentages 2026-2030: 130%, 124%, 117%, 109%, 100%.

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PR OF CHINA - FUEL CONSUMPTION STANDARDS FOR LIGHT COMMERCIAL VEHICLES

Light-duty commercial vehicles (GB 20997-2015)

Maximum fuel consumption standards applicable for N_1 and M_2 vehicles (GVW $\leq 3,500$ kg) 1 January 2020 for vehicles in production (certified before 1 January 2018).

N_1 vehicles fuel consumption limit multiple 1.05, if meeting one or multiple criteria:

- a) N_1 box truck
- b) N_1 bucket truck
- c) N_1 All-wheel-drive truck

Fuel consumption targets

Curb Mass (CM), kg	N_1 vehicles		M_2 vehicles	
	Gasoline (L/100 km)	Diesel (L/100 km)	Gasoline (L/100 km)	Diesel (L/100 km)
$CM \leq 750$	5.5	5	5	4.7
$750 < CM \leq 865$	5.8	5.2	5.4	5
$865 < CM \leq 980$	6.1	5.5	5.8	5.3
$980 < CM \leq 1,090$	6.4	5.8	6.2	5.6
$1,090 < CM \leq 1,205$	6.7	6.1	6.6	5.9
$1,205 < CM \leq 1,320$	7.1	6.4	7	6.2
$1,320 < CM \leq 1,430$	7.5	6.7	7.4	6.5
$1,430 < CM \leq 1,540$	7.9	7	7.8	6.8
$1,540 < CM \leq 1,660$	8.3	7.3	8.2	7.1
$1,660 < CM \leq 1,770$	8.7	7.6	8.6	7.4
$1,770 < CM \leq 1,880$	9.1	7.9	9	7.7
$1,880 < CM \leq 2,000$	9.6	8.3	9.5	8
$2,000 < CM \leq 2,110$	10.1	8.7	10	8.4
$2,110 < CM \leq 2,280$	10.6	9.1	10.5	8.8
$2,280 < CM \leq 2,510$	11.1	9.5	11	9.2
$2,510 < CM$	11.7	10	11.5	9.6

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PR OF CHINA - PHASE IV FUEL CONSUMPTION STANDARDS FOR LIGHT COMMERCIAL VEHICLES

Phase IV standards for individual vehicles (GB 20997-2024)

L/100 km targets are to be introduced in January 2026 based on test mass.

Category		Test mass $\leq 1,190$ kg	$1,190$ kg < Test mass $\leq 2,850$ kg	Test mass > 2,850 kg
Gasoline	Truck (N_1)	4.27	$0.00263 \times (TM - 1,733) + 5.70$	8.64
	Bus (M_2)	4.11	$0.00270 \times (TM - 1,733) + 6.56$	8.59
Diesel	Truck (N_1)	3.64	$0.00208 \times (TM - 2,098) + 4.77$	7.09
	Bus (M_2)	3.54	$0.00202 \times (TM - 2,098) + 5.37$	6.89

Notes: For vehicles with dump truck configuration, the per-vehicle limits are 5% higher than the limits for trucks

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PR OF CHINA - PHASE IV FUEL CONSUMPTION STANDARDS FOR LIGHT COMMERCIAL VEHICLES

Phase IV CAFC standards

L/100 km targets are to be introduced in January 2026 based on test mass (TM).

Category		Test mass $\leq$ 1,190 kg	1,190 kg < Test mass $\leq$ 2,850 kg	Test mass > 2,850 kg
Gasoline	Truck (N ₁)	6.09	$0.00375 \times (TM - 1,733) + 8.13$	12.32
	Bus (M ₂)	5.85	$0.00375 \times (TM - 1,733) + 8.13$	12.25
Diesel	Truck (N ₁)	5.19	$0.00385 \times (TM - 2,098) + 9.35$	10.13
	Bus (M ₂)	5.03	$0.00288 \times (TM - 2,098) + 7.65$	9.82

The targets are introduced according to a phase in based on a percentage of the final target.

CAFC target = 5 L/100 km				
2026	2027	2028	2029	2030
124%	124%	115%	115%	100%

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PR OF CHINA - NEW ENERGY VEHICLES

New energy vehicle (NEV) program and targets

The China New Energy Vehicle (NEV) program (revised 2020 and 2025) requires that credits be produced equivalent to a weighted percent of sales.

NEV credits can be earned for:

- Plug-in Hybrid Electric Vehicles (PHEV) – currently up to 1.6 per vehicle
- Battery Electric Vehicles (BEV) – currently up to 5.1 per vehicle. (3.4 maximum base credits with up to 1.5x multiplier for efficient vehicles)
- Fuel Cell Electric Vehicles (FCEV) – currently up to 6 per vehicle

Model year	GB 27999-2019 CAFC III
2019	10%
2020	12%
2021	14%
2022	16%
2023	18%
2024	28%
2025	38%
2026	48%
2027	58%

1. PHEV credit 2024-2025

PHEV receive a credit if both the following conditions are met:

- Fuel Consumption in charge sustaining mode < 70% of phase 5 target
- Electric energy consumption in charge depleting mode is greater than 135% of the electric energy consumption target (E_t - see next page)

(See PR of China section on CO₂/FE for phase 5 fuel consumption targets).

2. PHEV credit 2026-2027

Same as above with thresholds at 60% and 130% respectively.

3. FCEV credit (2024-2025 and 2026-2027)

Credit = 0.05 x fuel cell rated power (maximum 4).

If fuel cell rated power < 30% of rated power of drive motor or 10 kW

Credit = 0.025 x fuel cell rated power (maximum 2).

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PR OF CHINA - NEW ENERGY VEHICLES

BEV credit 2024 - 2025

BEVs receive a standard credit dependent on all electric range (AER):

Standard credit (C_{std})

AER	C_{std}
$AER < 100 \text{ km}$	0.0
$100 \text{ km} \leq AER \leq 150 \text{ km}$	0.6
$150 \text{ km} \leq AER$	$0.0034 \times AER + 0.2$ (maximum 2.3)

Further multipliers are applied according to energy consumption vs. a target, AER and battery energy density:

$$\text{Total BEV credit} = C_{std} \times F_r \times F_e \times F_d$$

Where:

- F_r = Driving range factor (from 0 to 1)
- F_e = Power consumption factor (from 0.5 to 1.5)
- F_d = Energy density factor (from 0 to 1)

See tables on right hand side.

1. BEV credit 2026 - 2027

Same as above except F_e maximum 1.2 with stricter ratios and additional factor for efficient cab heating maximum 1.2.

2. Driving range adjustment factor (F_r)

All Electric Range (AER)	F_r
$AER < 100 \text{ km}$	0.0
$100 \text{ km} \leq AER \leq 150 \text{ km}$	0.7
$150 \text{ km} \leq AER \leq 200 \text{ km}$	0.8
$200 \text{ km} \leq AER \leq 300 \text{ km}$	0.9
$300 \text{ km} < AER$	1.0

3. Electric energy consumption target (E_t) 4. Power consumption factor (F_e)

Curb Mass (M) (kg)	(E_t) kWh/100 km	Condition	F_e
$M \leq 1,000 \text{ kg}$	$0.4 + 0.0112 \times M$	$(E_t / EEC) < 1$	0.5
$1,000 \text{ kg} < M \leq 1,600 \text{ kg}$	$3.81 + 0.0078 \times M$	$1 < (E_t / EEC) \leq 1.5$	(E_t / EEC)
$1,600 \text{ kg} < M$	$8.6 + 0.0048 \times M$	$1.5 < (E_t / EEC)$	1.5

5. Energy density adjustment coefficient (F_d)

Battery Energy Density (D)	F_d
$D < 90 \text{ Wh/kg}$	0
$90 \text{ Wh/kg} \leq D < 105 \text{ Wh/kg}$	0.8
$105 \text{ Wh/kg} \leq D < 125 \text{ Wh/kg}$	0.9
$125 \text{ Wh/kg} \leq D$	1

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INDIA - CAFE NORMS

Corporate average fuel economy

Corporate Average Fuel Efficiency (CAFE) norms were first notified by the Government in 2015, under the Energy Conservation Act, 2001 to mitigate fuel consumption by lowering CO₂ emissions.

These norms are applicable for petrol, diesel, liquefied petroleum gas (LPG), CNG, hybrid, and electric passenger vehicles with gross vehicle weight (GVW) < 3,500 kg.

It relates the gasoline equivalent corporate average fuel consumption (in liters/100 km) to the corporate average kerb weight of all the cars sold by any manufacturer in a fiscal year.

These standards were introduced in two phases:

	CAFE stage I	CAFE stage II
Effective year	2017-18 onwards	2022-23 onwards
Average kerb weight (kg)	1,037	1,082
Fuel Consumption (L/100 km)	< 5.5	< 4.78
Average CO ₂ emissions (grams of CO ₂ /km)	< 130	< 113

Each manufacturer shall comply with energy consumption standard in terms of Average Fuel Consumption Standards as provided in the table below:

Where W is the Weighted average of unladen mass in kilogram (kg).

Year	Test cycle	Average fuel consumption standard (petrol equivalent L/100 km)
Fiscal year from 2017/18 to 2021/22	MIDC	$0.0024 \times (W - 1,037) + 5.4922$
Fiscal year from 2022/23 onwards	MIDC	$0.002 \times (W - 1,145) + 4.7694$

The CO₂ (g/km) measured over the MIDC cycle, multiplied by a factor taking into account the fuel type, gives the actual fuel consumption FC.

Type of fuel	FC (L/100 km for petrol, LPG and diesel, kg/100 km for CNG)	Conversion factor to petrol equivalent
Petrol	$0.04217 \times \text{CO}_2$	–
Diesel	$0.03776 \times \text{CO}_2$	1.1168
LPG	$0.06150 \times \text{CO}_2$	0.6857
CNG	$0.03647 \times \text{CO}_2$	1.1563
Electricity	$(\text{FC in kWh/100 km}) \times \text{CO}_2$	0.1028

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INDIA - CAFE NORMS

1. Super credits

For the purpose of calculating the Corporate Average CO₂ Performance (P), a manufacturer may consider using the volume derogation factor given below, for each of its models:

	Vehicle types	Volume derogation factor for super credit
1	Strong Hybrid Electric Vehicles	2
2	Plug-in Hybrid Electric Vehicles / Range Extender Hybrid Electric Vehicles	2.5
3	Pure Electric Vehicles Hydrogen (FCEV)	3

2. CO₂ reducing technologies

The vehicle manufacturer, may use the following factors for the following CO₂ reducing technologies in calculating the Corporate Average CO₂ Performance.

The technology factor for vehicles using multiple technologies shall be the multiplication of individual factors.

Derogation factors for CO₂ reduction technologies

CO ₂ reducing technologies	Derogation factor on CO ₂ emission
Regenerative braking	0.98
Start-Stop system	0.98
Tyre pressure monitoring system	0.98
6 or more speed transmission	0.98



INDIA - CAFE NORMS

Development of CAFE III standards (September 2025 draft from the Bureau of Energy Efficiency)

Each manufacturer of four-wheeled motor vehicles shall comply with energy consumption standards in terms of Average Fuel Consumption Standards as provided below:

The Annual Average Fuel Consumption Standard = $a \times (W - b) + c$.

W = weighted average of unladen mass in kilogram (kg) of all said motor vehicles, manufactured or imported for sale by the manufacturer in the reporting period.

The test cycle remains MIDC but testing on iWLTC will be required when notified by MoRTH.

Other factors, see table:

Year	FY 2027-2028	FY 2028-2029	FY 2029-2030	FY 2030-2031	FY 2031-2032
a (liters per 100 kilometers)	0.002				
b (kilograms)	1170				
c (liters per 100 kilometers per kilograms)	3.7264	3.5737	3.4573	3.2224	3.0139
c in CO ₂ equivalent (g/km)	88.4	84.7	82.0	76.4	71.5
Average Fuel Consumption Standard for Manufacturer in petrol equivalent (liters per 100 kilometers)	$[0.002 \times (W - 1170) + c]$				

The proposal maintains the derogation factors on the previous page and adds a 1.5 factor for Flex Fuel Ethanol Vehicles.

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JAPAN - CORPORATE AVERAGE FUEL ECONOMY STANDARDS

2015 fuel economy standard

The regulation considers diesel and gasoline vehicles together.

Test cycle

$$\text{FE JC08 total} = 1 / (0.25/\text{FE JC08}_{\text{cold}} + 0.75/\text{FE JC08}_{\text{hot}})$$

A correction factor is applied to account for the heating value of fuels other than gasoline:

- Diesel FE = FE JC08 total / 1.1
- LPG FE = FE JC08 total / 0.78

Passenger Cars – Targets for 2015

Ref. mass (kg)	≤ 600	601-740	741-855	856-970	971-1,080	1,081-1,195	1,196-1,310	1,311-1,420
km/L	22.5	21.8	21	20.8	20.5	18.7	17.2	15.8
Ref. mass (kg)	1,421-1,530	1,531-1,650	1,651-1,760	1,761-1,870	1,871-1,990	1,991-2,100	2,101-2,270	≥ 2,271
km/L	14.4	13.2	12.2	11.1	10.2	9.4	8.7	7.4

2020 fuel economy standard

The 2020 standard represents a 19.6% increase in fuel economy overall with the same limit structure.

Passenger Cars – Targets for 2015

Ref. mass (kg)	≤ 740	741-855	856-970	971-1,080	1,081-1,195	1,196-1,310	1,311-1,420	1,421-1,530
km/L	24.6	24.5	23.7	23.4	21.8	20.3	19	17.6
Ref. mass (kg)	1,531-1,650	1,651-1,760	1,761-1,870	1,871-1,990	1,991-2,100	2,101-2,270	≥ 2,271	
km/L	16.5	15.4	14.4	13.5	12.7	11.9	10.6	

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JAPAN - CORPORATE AVERAGE FUEL ECONOMY STANDARDS

2030 fuel economy standard

The 2030 standard requires a fleet average fuel economy of 25.4 km/L, a 25% increase compared to the 2020 standard.

The structure is maintained but the discrete weight bins are replaced by a continuous weight-dependent curve (right-hand side).

The test cycle changes to WLTC.

Electric vehicles are included with $FE = 6,750 / EC$, where:

EC = AC power consumption (Wh/km).

Plug-in hybrid fuel economy is calculated as:

$$UF \times \left(\frac{1}{FE_{CD}} + \frac{1}{6.75 \times \frac{R_{CD}}{E_1}} \right) + \frac{1 - UF}{FE_{CS}}$$

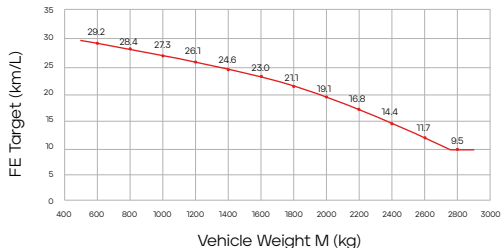
UF = utility factor (see chart).

FE_{CD} / FE_{CS} = fuel economy in charge depleting / charge sustaining mode.

R_{CD} = electric vehicle range.

E_1 = energy consumption per charge.

2030 FE target curve



M below 2,759 kg: $FE \text{ target} = -2.47 \times 10^{-6} \times M^2 - 8.52 \times 10^{-4} \times M + 30.65$.

M above 2,759 kg: $FE = 9.5$.



SOUTH KOREA

Corporate average fuel consumption and GHG limits

South Korea applies a dual system - Fuel Economy (CAFE) by MOTIE (Ministry of Trade, Industry and Energy) and GHG emissions standards by the Ministry of Environment. Both are based on corporate average values for each automaker. These regulations apply to passenger cars and light commercial vehicles (≤ 3.5 tonnes, ≤ 15 seats). Zero-emission vehicles (ZEVs) such as BEVs and FCEVs receive compliance credits under separate calculation rules.

Fuel consumption and GHG limit values

Standard	Vehicle category	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Remark
FC in km/L	Passenger car, Van (≤ 10 people)	24.3	24.3	24.4	25.2	26	27	27.9	29	30.9	33.1	Not Fixed (Guideline)
	Van (11 - 15 people), Small Truck (≤ 3.5 tonne)	15.2	15.2	15.4	15.7	16	16	16.3	16.6	16.9	17.3	
GHG in g/km	Passenger car, Van (≤ 10 people)	97	97	95	92	89	86	83	80	75	70	Released
	Van (11 - 15 people), Small Truck (≤ 3.5 tonne)	166	166	164	161	158	158	155	152	149	146	

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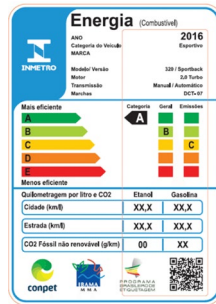


Brazilian Vehicle Labeling Program (PBEV)

- Coordinated by Inmetro, in partnership with the Ministry of Mines and Energy (MME), the PBEV evaluates and classifies the energy efficiency of new vehicles sold in Brazil
- The program is voluntary for vehicle manufacturers, but most of them adhere to it and renew their participation annually
- The National Energy Conservation Label (ENCE) is affixed to the vehicles' windows and includes the following information:
 - Rating:** Varies from **A (most efficient)** to **E (least efficient)**, for both in-category and overall comparison. The most efficient rating is represented by the color green, and the least efficient by red (see next page)
 - Fuel consumption:** Indicates the vehicle's average consumption in km/liter, both in the city and on the highway, with different fuels (gasoline, ethanol, etc.)
 - CO₂ emissions:** Details the carbon dioxide (CO₂) emissions for combustion vehicles
 - Range:** For electric and hybrid vehicles, it informs the range in distance covered with a battery charge

Conpet Energy Efficiency Seal

- The Conpet Seal is awarded to vehicles that obtain the best rating (usually an "A" grade) on the Inmetro label
- The label classifies all participating PBEV vehicles, while the seal is a special recognition for the most efficient in their category
- A vehicle with a Conpet Seal guarantees the owner greater fuel savings, as its energy consumption is lower. In addition, the seal contributes to awareness about the efficient use of fossil fuels
- The seal is an initiative of the National Program for the Rationalization of the Use of Petroleum and Natural Gas Derivatives (Conpet)



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BRAZIL

Energetic fuel consumption calculations - basics

- 1a. Measure E20 + E100 Urban cycle / City cycle / EPA75 =
(norm ABNT NBR 660)
- 1b. Measure E20 + E100 Highway cycle (norm ABNT NBR 7024)
2. Calculate final fuel consumption = measured fuel consumption
x factor (Portaria n 377)
3. Calculate combined fuel consumption for E22 and E100 =
55% Urban + 45% Highway
4. Calculated energetic E22 and E100 fuel consumption in MJ/km
based on MJ/kg using the follow factors to convert from volumetric
consumption (L/km or to be determined for CNG):

Physical characteristics	Unit	E00	E22	E100	Unit	CNG
Calorific Power	MJ/kg	43.06	38.92	24.8	MJ/kg	48.74
Density	kg/L	0.735	0.745	0.807	kg/m ³	0.723
Energy Density	MJ/L	31.65	28.99	20.01	MJ/m ³	35.24

5. Calculate final energetic fuel consumption in MJ/km, being is the
average of the combined E20 and E100 MJ/km

Vehicle Labeling Program

The Brazilian Vehicle Labeling Program categorizes vehicles into efficiency classes A to E based on their energetic consumption and vehicle segment.

Energetic consumption (EC) ranges for categories A to E (MJ/kg)

PBE classification	Subcompact	Medium	Compact	Large
A	EC ≤ 1.60	EC ≤ 1.76	EC ≤ 1.76	EC ≤ 1.95
B	1.60 < EC ≤ 1.67	1.76 < EC ≤ 1.84	1.76 < EC ≤ 1.84	1.95 < EC ≤ 2.04
C	1.67 < EC ≤ 1.78	1.84 < EC ≤ 1.90	1.84 < EC ≤ 1.94	2.04 < EC ≤ 2.24
D	1.78 < EC ≤ 1.92	1.90 < EC ≤ 2.00	1.94 < EC ≤ 2.04	2.24 < EC ≤ 2.53
E	EC > 1.92	EC > 2.00	EC > 2.04	EC > 2.53

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UNITED KINGDOM

Zero-emission vehicle (ZEV) mandate

The ZEV mandate, introduced via the Vehicle Emissions Trading Scheme (VETS) legislation in 2023, sets annual targets for the percentage of each manufacturer's sales of new passenger cars (PC) and light commercial vehicles (LCV) that must be ZEVs. Only battery electric and fuel cell electric vehicles count towards the ZEV requirement.

From 2024 to 2026, part of the ZEV requirement in each year can be borrowed from future years, and repaid by overcompliance with the targets by 2027 at the latest.

Manufacturers can partially comply with the ZEV requirement by a achieving non-ZEV CO₂ fleet average lower than a baseline equal to the higher of their actual 2021 fleet average CO₂ or their 2021 fleet average target.

Non-compliance penalties are £15,000 / £18,000 for each PC or LDV respectively below the target in each year.

The following table shows the legislated targets:

Year	2024	2025	2026	2027	2028	2029	2030
PC	22%	28%	33%	38%	52%	66%	80%
LCV	10%	16%	24%	34%	46%	58%	70%

Indicative targets to be set in future legislation

Year	2031	2032	2033	2034	2035
PC	84%	88%	92%	96%	100%
LCV	76%	82%	88%	94%	100%

In December 2024 the Department for Transport started a consultation on proposed amendments to introduce additional flexibilities and reduce the penalties, maintaining the headline targets, expected to be adopted by the end of 2025.

OTHER AREAS OF THE WORLD

Australia	Mandatory CO ₂ emissions standards (New Vehicle Efficiency Standard - NVES) for light duty vehicles apply from 2025: Passenger Cars – CO ₂ g/km: 141 in 2025 / 117 in 2026 / 92 in 2027 / 68 in 2028 / 58 in 2029 LCV – CO ₂ g/km: 210 in 2025 / 180 in 2026 / 150 in 2027 / 122 in 2028 / 110 in 2029 Based on NEDC CO ₂ measurement 1 st review planned in 2026 – targets for 2030 – 2035 could be considered
Canada	In place from MY 2017 – Adoption in 2014: requirement of 5% annual reduction in CO ₂ -equivalent per mile for passenger cars from 2017 to 2025 (3.5% the first 3 years, then 5% for Light trucks)
Mexico	Phase 2 CO ₂ emissions standard (NOM 163) for LDVs, enacted in January 2024, is setting g CO ₂ /km targets for 2025-2027 for Manufacturers: The annual targets are set to achieve 89 g CO ₂ /km for passenger cars and 131 g CO ₂ /km for LCVs by 2027 Mexico announced a target of 50% of new LDV sales to be zero-emission by 2030
New Zealand	Annual GHG standards for new LDV imported into the country: LDV – CO ₂ (g/km): 112.6 in 2025 / 84.5 in 2026 / 63.3 in 2027 LCV – CO ₂ (g/km): 155 in 2025 / 116.2 in 2026 / 87.2 in 2027
South Africa	Vehicle tax introduced in 2010 based on CO ₂ emissions of each vehicle model – payed by manufacturer or importer
Taiwan	Fuel economy standards have been in place since August 2014 The current one (2022) is based on "Energy Efficiency Standards", function of engine displacements and vehicle categories, for manufactured or imported vehicles

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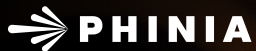
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WE'RE ADVANCING
SUSTAINABILITY THROUGH
PRODUCT ENGINEERING
AND INNOVATION,
WHILE REDUCING THE
ENVIRONMENTAL FOOTPRINT
OF OUR OPERATIONS.



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EUROPEAN UNION - EURO 3-4 OBD

European on-board diagnostics

OBD identifies malfunctions and deterioration that cause emissions to exceed thresholds. Driver is notified upon detection.

The Euro OBD stages are presented in chronological order to show the development of their provisions over time.

Euro 3-4

- OBD based on European revised urban + extra-urban cycle (NECD)
- Onboard diagnostics was first introduced with Euro 3 emission limits ($M_1 \leq 2.5$ t GVW, N_1 CL 1 type approval 1/2000, first registration 1/2001)
- No OBD Euro 4 step was foreseen

EOBD Thresholds Euro 3-4 (g/km)

Vehicle class	CO		HC		NOx		PM
	PI	CI	PI	CI	PI	CI	CI
$M_1 \leq 2.5$ t GVW, N_1 CL 1	3.20	3.20	0.40	0.40	0.60	1.20	0.18
N_1 CL 2	5.80	4.00	0.50	0.50	0.70	1.60	0.23
N_1 CL3, $M_1 > 2.5$ t GVW	7.30	4.80	0.60	0.60	0.80	1.90	0.28

PI = positive ignition engines, CI = compression ignition engines.

Monitoring areas according to engine type

Monitor area	PI	CI
Catalyst converter (gasoline THC only)	X	X
Engine misfire	X	
Oxygen sensor deterioration	X	
Particulate trap		X
Fuel injection system	X	X
Circuit continuity of all emission related powertrain components	X	X
Any other emissions related components or systems (air flow, EGR, etc) if malfunction causes increase above thresholds	X	X

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EUROPEAN UNION - EURO 5 OBD

Euro 5 OBD requirements

UN Reg 83, Annex 11 requirements applicable, in addition to following points: as outlined in 70/220EC; 715/2007EC and 692/2008EC.

Thresholds Euro 5 in mg/km

Vehicle class	Implementation date	CO		NMHC		NOx		PM	
		PI	CI	PI	CI	PI	CI	PI ^a	CI ^b
M, N ₁ CL 1	TA 9/2009 FR 9/2011	1,900	1,900	250	320	300	540	50	50
N ₁ CL 2	TA 9/2010 FR 9/2012	3,400	2,400	330	360	375	705		
N ₁ CL 3, N ₂		4,300	2,800	400	400	410	840		

^aFor GDI engines only.

^b80 mg/km until 1 September 2011, for M and N vehicles with RM > 1,760 kg.

^cMandatory total failure or removal detection if emission limit exceeded for DOC, DeNOx catalysts and DPF.

^dEuro 5+ OBD TA: 1 September 2011 / FR: 1 January 2014.

Expanded Monitoring areas starting Euro 5

EGR system efficiency monitoring
EGR flow and cooler monitoring
Catalyst against NMHC ^b
Catalyst against NOx (> Euro 5+) ^{c,d}
NOx aftertreatment device with or without reagent efficiency monitoring ^c
All O ₂ Sensors to monitor catalyst (in addition to front sensor)
PM monitoring ^c
IUPR (> Euro 5+) ^d

- Access to OBD information
 - Similar to UN Reg 83 requirements
 - Access with generic scan tool, complying with ISO 15031-5 document
- Functional aspects of OBD systems
 - Technical requirements are similar to UN Reg 83
 - Starting Euro 6, on-board and off-board communication standard: ISO 15765-4 (CAN)



EUROPEAN UNION - EURO 6 OBD

Euro 6 OBD requirements

Thresholds Euro 5 in mg/km

Euro 6-1	Implementation date	CO		NMHC		NOx		PM	
		PI	CI	PI	CI	PI	CI	PI	CI
M, N ₁ CL 1	NT 9/2014 NV 9/2015	1,900	1,750	170	290	150	180	25	25
N ₁ CL 2	NT 9/2015 NV 9/2016	3,400	2,200	225	320	190	220	25	25
N ₁ CL 3, N ₂		4,300	2,500	270	350	210	280	30	30
Euro 6-2		PI	CI	PI	CI	PI	CI	PI	CI
M, N ₁ CL 1	NT 9/2017 NV 9/2018	1,900	1,750	170	290	90	140	12	12
N ₁ CL 2	NT 9/2018 NV 9/2019	3,400	2,200	225	320	110	180	12	12
N ₁ CL 3, N ₂		4,300	2,500	270	350	120	220	12	12

Demonstration Cycle

- September 2017 to September 2019-OEM is flexible to choose NEDC or WLTP cycle for OBD threshold part creation and demonstration
- Beyond September 2019 WLTC only

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Additional requirement starting Euro 5+^a:

In Use Performance Ratio monitoring (IUPR)

IUPR indicates how often a specific monitor (diagnostic function) is operating relative to vehicle operation:

$$\text{IUPR} = \frac{\text{Numerator}_M}{\text{Denominator}_M}$$

Numerator_M measures number of times a monitoring function has run and a malfunction could have been detected.

Denominator_M measures the number of vehicle driving events taking into account special conditions.

^aEuro 5+ OBD interim step with NT: 1 September 2011 / NV: 1 January 2014.



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Based on UNR154

$IUPR(m) = \text{Numerator}(m) / \text{Denominator}(m)$

(m) correspond to a monitor

Numerator of a specific monitor (m) is a counter indicating the number of times a vehicle has been operated such that all monitoring conditions necessary for that specific monitor to detect a malfunction have been encountered.

The general denominator is a counter indicating the number of times a vehicle has been operated, taking into account general conditions:

- Cumulative time since engine start is greater than or equal to 600 seconds while at an elevation of less than 2,440 m above sea level and at an ambient temperature of greater than or equal to -7°C
- Cumulative vehicle operation at or above 40 km/h occurs for greater than or equal to 300 seconds while at an elevation of less than 2,440 m above sea level and at an ambient temperature of greater than or equal to -7°C

- Continuous vehicle operation at idle (i.e. accelerator pedal release by driver and vehicle speed less than or equal to 1.6 km/h) for greater than or equal to 30 seconds while at an elevation of less than 2,440 m above sea level and at an ambient temperature of greater than or equal to -7°C

The numerator and denominator can be incremented only by +1 into a one driving cycle.

The value of minimum in-use-performance ratio $IUPR(\min)$ is 0.1 for all monitors.

Additionally, some specific conditions can be added for each monitor:

- System or actuator, VVT and system operating exclusively during cold start: Should be commanded "on" for time greater than 10 seconds
- DPF and DOC monitoring: 800 cumulative kilometer since the last incrementation of the denominator
- Boost monitor: general denominator condition plus boost pressure control system is active for a time greater than or equal to 15 seconds

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IUPR thresholds

	Euro 5a	Euro 5b	Euro 5b+	Euro 6b		Euro 6c/d		Comments
				PI	CI	PI	CI	
Catalyst	-	-	0.1	0.336	0.336	0.336	0.336	
EGR system	-	-	0.1	0.336	0.336	0.336	0.336	
O ₂ sensors	-	-	0.1	0.336	0.336	0.336	0.336	
NOx sensors	-	-	0.1	0.336	0.336	0.336	0.336	
NOx aftertreatment system	-	-	0.1	0.336	0.1	0.336	0.336	
Secondary air	-	-	0.1	0.26	N/A	0.26	N/A	
Cold start diagnostics	-	-	-	0.26	0.26	0.26	0.26	Incremented only after cold start < 35°C coolant
VVT system	-	-	0.1	0.336	0.336	0.336	0.336	
Boost pressure control	-	-	0.1 (only CI)	-	0.336	-	0.336	Normal denominator + boost control active > 15 sec.
EVAP system	-	-	0.1	0.52	N/A	0.52	N/A	
Diesel oxidation catalyst	-	-	0.1	0.336	0.336 ^a	0.336	0.336 ^a	
Particulate filter	-	-	0.1 (only CI)	-	0.336 ^a	-	0.336 ^a	

^a Additional monitoring requirement of total failure or removal.

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EUROPEAN UNION - EURO 7 OBD AND OBM

Euro 7 OBD and OBM requirements

Euro 7 emissions limits and corresponding thresholds (mg/km) for OBD and OBM (new - see below)

	CO		NMHC		NOx		PM	
	PI	CI	PI	CI	PI	CI	PI	CI
Emission limits	1,000	500	68	170 (NOx + HC)	60	80	4.5	4.5
OBD Limits	1,900	1,750	170	290	90	140	12	12
OBM Limits	N/A	N/A	N/A	N/A	150	200	11.25	11.25

Euro 7 requires monitoring of tailpipe emissions:

1. OBD regulation: equivalent to Euro 6 and must comply with UNR 154
2. On-board monitoring (OBM): Measurement of tailpipe emissions for NOx and PM and NH₃ (only HD)

Euro 7 OBM regulation is split in two parts:

a. Vehicle level:

- i) Provide instantaneous OBM data at 1 Hz on OBD port (Emissions measurement and environmental conditions)
- ii) Memorize emissions results of the last 10 trips
- iii) Memorize emissions results for vehicle life

b) Type approval level:

- i) Vehicle must report OBM data for trips randomly selected
 - ii) OBM selected data must be sent Over the Air periodically
 - iii) OEM has to provide OBM data to authorities annually
3. When tailpipe emissions exceed 2.5 times the standard emission limits, Excess Exhaust Emissions Driver Warning System (EEEDWS) must be activated

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US AND CALIFORNIA - EPA OBD II

US on-board diagnostics

EPA Tier 3 requirements are harmonized with CARB requirements. Minor exceptions are outlined below.

EPA harmonization final rule: Conditions for malfunction in each monitor area

Monitor area	Condition for malfunction
Catalysts Engine Misfire, O ₂ Sensors	OBD Threshold = 1.5 x standard measured on FTP test
EVAP System	Leakage equivalent to a 0.020" hole
EPA Tier 3 Comments	EPA Tier 3 requires that vehicle must comply with CARB OBD II regulations by 2017 MY except for the following exceptions: Demonstration of crankshaft/camshaft alignment is only required for VVT equipped vehicles



US AND CALIFORNIA - CARB (AND EPA) OBD II

Monitoring requirements and conditions for malfunction in each monitor area for all vehicles (from MY 2015)

Monitor area	Malfunction criteria
Engine Cooling System - Thermostat	- Engine coolant temperature does not reach the following within Executive Officer approved time: - Within 20°F of normal operating temp. (may use higher threshold if < 50% emissions increase) - Highest temp. required by the OBD system to enable other monitors - For 30% of MY 2019, 60% of MY 2020, and 100% of MY 2021: Engine coolant temperature reaches the thermostat target, but then subsequently drops. May disable monitor when IAT < 20°C, engine coolant temperature at startup is 35°F less than malfunction threshold, or during conditions cause false results
Engine Cooling System - Engine Coolant Temperature Sensor	(The manufacturer must submit a monitoring plan for systems that make use of more than one sensor to indicate engine temperature) - Lack of circuit continuity - Time to reach feedback enable temp. exceeds: - Gasoline Engines: 2 min. for start-up temp. up to 15°F below closed-loop threshold. 5 min. for start-up temp. between 15-35°F below closed-loop threshold (applies to stoichiometric feedback for 30% of fleet in MY 2019, 60% in MY 2020, 100% in MY 2021, manufacturer may choose for remainder of fleet) - Diesel Engines: Manufacturer-defined (and Executive Officer approved) time limit (May suspend/delay timer for conditions that could lead to false diagnosis) - Stuck in range below the highest min. enable temp. required by other monitors - Stuck in range above the lowest max. enable temp. required by other monitors (exemption allowed: temp. gauge is based on same sensor and indicates overheat)

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Monitoring requirements and conditions for malfunction in each monitor area for all vehicles (cont.)

Monitor area	Malfunction criteria (and/or system requirements)
Crankcase Ventilation (CV) - Includes all CV-related external tubing/hoses	• Disconnection of CV system between Crankcase and CV Valve and/or CV Valve and Intake Ducting • For 20% of MY 2023, 50% of MY 2024, and 100% of MY 2025+ vehicles: leak in CV system (greater than the smallest internal hose cross-section) between Crankcase and CV Valve and/or CV Valve and Intake Ducting. • Exemptions may apply with Exec. Officer approval for systems where vehicle operator is certain to respond or where disconnection or leak of an unmonitored portion first requires disconnection or leak of a monitored portion connection between: - Crankcase and CV Valve, when tubing is used such that it is resistant to deterioration or disconnection, difficult to remove relative to connection between CV Valve and Intake, and not part of non-CV repair/maintenance - CV Valve and Intake, if it causes the vehicle to stall, or is unlikely due to CV design being integral to the induction system (no tubing, hoses, etc.)
Comprehensive Components	(System requirements: • Monitoring of any input or output component that can impact emissions under any reasonable driving condition • Those components/systems that affect only engine mechanical or electrical load (not related to fuel, air, or emissions control) are only to be monitored if they are used by any other system or component monitor • For hybrid vehicles, monitoring requires Exec. Officer approval: manufacturers must monitor components that are emissions related and/or are used as inputs to OBD monitor(s), except for: - The following systems if they do not meet either of the 2 conditions above: Energy Storage, Thermal Management, Regenerative Braking, Drive Motor, Generator, Plug-In ESS charger - Hybrid electronic components use for inverter thermal management that are commanded solely by the driver • Monitoring not required when both of the following are met for the component: - Malfunctions may not cause emissions to increase by: 25% or more (PC/LDT SULEV II); 15% or more (all other vehicles) - The component or system is not used as part of another diagnostic strategy)

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Monitoring requirements and conditions for malfunction in each monitor area for all vehicles (cont.)

Monitor area	Malfunction criteria
Comprehensive Components - Input Components	• Lack of circuit continuity or loss of communication (for digital inputs) • Out of 'normal' range • Irrational sensor value (2-sided monitoring) • Components used for emission control strategies not specifically addressed by CARB regulations: - Failures that cause the strategy not to operate in its intended manner (delayed enable, erroneous exit, authority limit) • Camshaft/Crankshaft Position Monitoring (for engines requiring precise cam/crank alignment with sensors on both shafts): - Alignment malfunction of 1 tooth (or more if no emissions impact): MY 2006-2018 = VVT with belt/chain; MY 2019+ = with or without belt/chain
Comprehensive Components - Output Components	• Improper functional response, as feasible • Circuit continuity faults • Idle Control System (gasoline engines with monitoring strategies based on deviation from target idle speed): - Speed control cannot maintain within 200 rpm above or 100 rpm below the target idle speed - Speed control cannot maintain within the smallest engine speed tolerance range for enabling any other monitor - For diesel Engines • Idle Control System: - Speed control cannot maintain within +/- 30% of target speed - Speed control cannot maintain within the smallest engine speed tolerance range for enabling any other monitor - Idle control cannot achieve the target idle speed with fuel injection quantity within (smallest quantity tolerance range for enabling other monitors) OR (+/- 50% of properly functioning quantity)

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Monitoring requirements and conditions for malfunction in each monitor area for all vehicles (cont.)

Monitor area	Malfunction criteria
Comprehensive Components - Output Components (cont.)	• Detection of a Stall event (20% of 2026, 50% of 2027, 100% of 2028+): - Within 20 seconds of engine start, where fuel level $\geq$ 15% nominal capacity - Fault codes must distinguish Cold Start fault from other engine conditions • Glow Plugs/Intake Air Heaters: - Improper functional response - Circuit continuity faults - Improper current and voltage drop - Single glow plug no longer operates in manufacturer's limits • 'Wait to start' Lamp: failures that prevent illumination • Components used for emission control strategies not specifically addressed by CARB regulations: - Failures that cause the strategy not to operate in its intended manner (delayed enable, erroneous exit, authority limit) • Tolerance Compensation: improper compensation being applied by controller for connected hardware, with no monitoring required if $< 15\%$ emission increase AND $<$ full useful life standard under test cycle (Exec. Officer review / approval required)

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Monitoring requirements and conditions for malfunction in each monitor area for all vehicles (cont.)

Monitor area	Malfunction criteria
In-Use Performance Ratio	Minimum performance ratios required: • 0.100 for Diesel Cold Start Emission Reduction Strategy • 0.260 for secondary air system, cold start monitors, and evaporative 0.020" leak • 0.336 for catalyst, oxygen sensors, EGR, VVT, high load purge flow, and remainder • 0.520 for low load purge flow, and evaporative 0.040" leak PM Filter Performance: • 0.200 (PC, LDT, MDPV chassis cert.) Interim year allowances: • PC, LDT, MDPV (chassis cert.): to 2021 = 0.100, to 2025 = 0.15, to 2028 = (0.336 for Option 1, 0.150 for Option 2) Exceptions: • Plug-in Hybrid Vehicles: through 2019 MY, minimum ratio = 0.100 for those monitors requiring engine run operation • Engine Certified MD Vehicles (2016–2018 MY) as well as Chassis Certified LD, MD and Passenger Cars (2019–2021 MY): min. ratio = 0.100 for Diesel PM filter performance and missing substrate (only if denominator 500 mi criteria not utilized) • OBD system must track and report Ratio information (Numerators/Denominators) for the following: – Gasoline: catalyst, exhaust gas sensors, evaporative 0.020" leak, EGR/VVT, secondary air system – Diesel: NOx adsorber, NMHC catalyst, PM Filter, boost pressure control – Fuel system cylinder imbalance

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US AND CALIFORNIA - CARB (AND EPA) OBD II

OBD II gasoline emissions thresholds (LEV III)

Exhaust standards		Monitor thresholds				Catalyst monitor thresholds
Vehicle Type	Vehicle Emission Category	NMOG + NOx Mult. ^c	CO Mult.	PM Mult.	PM (mg/mi)	NMOG + NOx Mult.
Passenger cars, Light- Duty Trucks and Chassis Certified MDPVs	LEV160 / ULEV125	1.50	1.50	N/A	17.50 ^a	1.75
	ULEV70 / ULEV50	2.00				2.00
	SULEV30 / SULEV20 ^b	2.50	2.50			2.50

^a Applies to 2019 and subsequent MY vehicles.

^b Manufacturer shall use the 2.5 times NMOG+NOx multiplier for vehicles not using the provision of section (e) (17.15).

^c Monitor threshold except catalyst.

Mult. = Multiplier to be used with the applicable standard (e.g. 2.0 times the NMOG+NOx standard).



US AND CALIFORNIA - CARB (AND EPA) OBD II

CARB allows relaxed OBD standards for EPA Tier 2 / Tier 3

Upon request from a manufacturer, CARB allows for the possibility to provide relaxed emission standards for Tier 2 and Tier 3 federal tailpipe emissions standards (gasoline and diesel).

Federal Tier 2 (Bins 3 or 4)

Manufacturers shall utilize the ULEV II vehicle NMOG and CO malfunction criteria (e.g. 1.5 x Bin 3 or Bin 4 NMOG and CO stds.) and the PC/LDT SULEV II vehicle NOx malfunction criteria (e.g. 2.5 x Bin 3 or Bin NOx stds.) (as defined in 40 CFR 86.1811-04, 5 August 2015).

Federal Tier 3 (Bins 85 or 110)

Manufacturers shall utilize the following malfunction criteria in accordance with the following table (with the NMOG+NOx and CO multipliers to be used with the applicable standard (e.g. 2 x NMOG+NOx std.) (as defined in 40 CFR 86.1811-17, 5 August 2015).

Threshold multipliers and threshold for Tier 3 relaxed standard

Tier 3 (Bins 85 or 110)	NMOG +NOx mult.	CO mult.	PM mult.	PM threshold (mg/mi)
Gasoline				
Monitors (except for catalyst)	1.85	1.50	N/A	17.50 ^c
Catalyst monitor	2.00	N/A	N/A	N/A
Diesel				
Monitors ^a	1.85	1.50	2.00	N/A
Aftertreatment monitors ^b	2.00	1.50 ^c	2.00 ^c	N/A
PM filter performance monitor	1.85 ^c	1.50 ^c	N/A	17.50

^a Applies to (f) (3.2.5), (f)(4)-(f)(7), (f)(9.2.2), (f)(12)-(f)(13).

^b Applies to (f) (1)-(f)(2), (f)(8), and (f)(9.2.4)(A).

^c Applies to MY 2019 onwards.

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US AND CALIFORNIA - CARB (AND EPA) OBD II

Monitoring requirements and conditions for malfunction in each monitor area for gasoline vehicles

Monitor area	Malfunction criteria
EGR (low + high flow rate) - Sec. Air (low flow rate)	• Thresholds: for Non-LEV III = 1.5 x std; For LEV III = ^a - Exception for increased rate monitoring when deterioration not detectable off-idle and results in immediate stall at idle • Monitoring required while control strategy is normally activated - Failure detected when control requesting flows below authority limit
Fuel System	• Fuel delivery system: For non-LEV III vehicles = 1.5 x std (all constituents); for LEV III = ^a • RO₂ Sensor Feedback Control: for Non-LEV III vehicles = 1.5 x std (all constituents); for LEV III = ^a • A/F ratio for one (or more) cylinders different due to cylinder specific issue (e.g. fuel injector, individual cam lift, etc.) - For Non-LEV III vehicles = 1.5 x std - For LEV III vehicles: LEV160, ULEV125 = ^a / ULEV50/70 = For 2014-2018 3x std; For 2019+ = ^a / SULEV 20/30 = ^a / For 2014-2018 4x std; For 2019+ = ^a • Control max. authority reached (if based on secondary oxygen sensor, also allowed to verify if control target achieved prior to failure) • Fails to begin control within Exec. Officer approved time interval (based on manufacturer supplied data)

^aRefer to Gasoline Emission Thresholds.

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US AND CALIFORNIA - CARB (AND EPA) OBD II

Monitoring requirements and conditions for malfunction in each monitor area for gasoline vehicles

Monitor area	Malfunction criteria
Misfire	Continuous monitoring for all positive engine torque speeds / loads from 2nd crankshaft revolution after engine start / 150 rpm below normal, warmed-up idle speed. • For non-LEV III = 1.5 x standard (all constituents); For LEV III = ^a • Min. misfire rate 2% for plug-in hybrid vehicles, 1% for non-plug-in vehicles (per 1,000 revolutions) • Single misfire rate detection in first 1,000 revolutions and 4 detections must occur in each 1,000 revolution block afterwards • Misfire rate that causes catalyst temperature to reach damaging levels must be detected (min. rate 5%) • Engines with automated shut-off/restart strategies must get Exec. Officer approval for re-enabling conditions
Evaporative System	• No purge flow (applies to all flow paths with the following exceptions): - High load purge lines (with EO approval) prior to phase-in completion (20% - 2019, 50% - MY 2020, 100% - MY 2021) - High load purge line that contributes < 1% of total mass flow on US06 • Cumulative evaporative system leak $\geq 0.020''$ orifice (may be revised upward for tank size > 25 gallons or < 1.5 x standard with Exec. Officer approval) NOTE: MIL illumination not required for approved alternate indicator for fuel cap missing or improperly secured. Alternate fuel engines require Exec. Officer approval of a strategy equating to gasoline.

^aRefer to Gasoline Emission Thresholds.

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Monitoring requirements and conditions for malfunction in each monitor area for gasoline vehicles (cont.)

Monitor area	Malfunction criteria
Exhaust Gas Sensors - (oxygen, A/F, NO _x , PM, incl. Primary and Secondary)	• Sensor Performance: - For Non-LEV III = 1.5 x standard (all constituents); For LEV III = ^a - (Primary sensors only): symmetric and asymmetric delay to respond and response rates, lean-to-rich and rich-to-lean (certification data/analysis required) • Lack of circuit continuity • Out of 'normal' range • Feedback: failure or deterioration causes fuel system to stop using that sensor as an input (default or open loop): - (Primary sensors only): delayed entry to closed loop • Monitoring Capability: any characteristic no longer sufficient for use as input to other monitoring strategy • NO_x activity (2022+ MY): Sensor not providing NO_x data when normally feasible (isolation to root cause input component required, where applicable)
Exhaust Gas Sensors Heaters	• Current or voltage drop no longer within sensor manufacturer's limit for normal operation • Faults that result in conflict between command and actual state of the heater

^aRefer to Gasoline Emission Thresholds.

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Monitoring requirements and conditions for malfunction in each monitor area for gasoline vehicles (cont.)

Monitor area	Malfunction criteria						
Variable Valve Timing and/or Control	• For Non-LEV III = 1.5x standard (all constituents); For LEV III = ^a – Target error (outside crank angle and/or lift tolerance) – Slow response						
Catalyst	Thresholds	NMOG	NOx	CO Mult.	PM Mult.	PM Threshold	NMHC Conversion Efficiency Loss
	LEV II, ULEV II, MDV SULEV II	1.75%	1.75%	N/A	N/A	N/A	50%
	SULEV II	2.5%	2.5%	N/A	N/A	N/A	50%
	LEV III	^a					
	For threshold purposes, the catalyst system is to be aged simultaneously (full catalyst volume). If fuel is shut off for misfiring cylinder, the monitored volume catalyst(s) must be aged simultaneously to the threshold limit, while unmonitored volume must be aged to the end of the vehicle's full useful life						
Cold Start Emission Reduction Strategy	• To 2025 MY (alternatively may apply 2026+): Any commanded element does not 'properly respond' • Deterioration: Non-LEV III = 1.5 x standard, LEV III = ^a • 2026 +: If any component or feature does not 'properly respond': fuel pressure, idle speed, VVT/L, split/multiple injections, charge motion, intake runner, swirl control, electronic wastegate position – Where 'properly respond' = by a robustly detectable amount, in the commanded direction, by an amount greater than otherwise without cold start strategy						

^a Refer to Gasoline Emission Thresholds.

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Monitoring requirements and conditions for malfunction in each monitor area for gasoline vehicles (cont.)

Monitor area	Malfunction criteria
Cold Start Catalyst Heating	• 2026+: Commanded (actual, if feasible) extra heat energy to catalyst – < 20% additional element/command OR fault causes > Tier 3 threshold
Heated Catalyst	• Target heating temperature not reached within time limit. Limit based on 1.75 x standard (for non-LEV III vehicles); for LEV III = ^a. Alternate strategy requires Exec. Officer approval
Air Conditioning System	• For non-LEV III vehicles: 1.5 x std; for LEV III = ^a – Monitoring required when off-idle fuel and/or spark modified when A/C system is on, or for A/C components used by other OBD monitors. Monitoring of all A/C components that may cause the system to invoke incorrect control
Direct Ozone Reduction (DOR)	(Monitoring for non-detectable ozone reduction required) • For Non-LEV III vehicles = NMOG ≤ 50%; For LEV III vehicles = NMOG ≤ 5 mg/mi • For Non-LEV III vehicles with NMOG credit > 50%: monitoring for loss of NMOG performance > 50% NMOG standard • For LEV III vehicles with NMOG credit > 5 mg/mi: monitoring for loss of NMOG performance > 5 mg/mi • DOR NMOG credit modifies malfunction criteria for other components (e.g. malfunction threshold = 1.5 x standard + DOR NMOG credit) NOTE: LEV III standard combines NMOG+NO_x.

^aRefer to Gasoline Emission Thresholds.

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Monitoring requirements and conditions for malfunction in each monitor area for gasoline vehicles (cont.)

Monitor area	Malfunction criteria
Cooling System; Crankcase Ventilation; Comprehensive Components	Refer to OBD II requirements for ALL VEHICLES (top of CARB OBD II section)
Other Emission Related Components or Systems	• Must request Exec. Officer approval prior to introduction on a particular vehicle. For air flow modifying devices (swirl, runner length, etc.), monitoring of the shaft(s) may suffice - Non-metal or segmented shafts require segment monitoring (verification that the furthest segment properly functions) - If more than one shaft to operate valves in multiple banks, not required to add more than one set of detection hardware
Exceptions to Monitoring Requirements	• Disabling allowed (with CARB approval) for: ambient temperature < 20°F, altitude > 8,000 ft, vehicle speed > 82+ mph, fuel volume < 15% of capacity, battery voltage < 11V, battery voltage > manuf. limit, during power take-off operation, or tire pressure default action

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Conditions for malfunction in each monitor area for diesel vehicles

Monitor area	Malfunction criteria
Misfire	• All Diesel Vehicles: one or more continuously misfiring cylinders • For all following vehicle categories: - All chassis certified Passenger Cars, LD Trucks and MDPVs with combustion sensor - Phase-in for Chassis certified MDPVs: 20% of 2019 MY, 50% of 2020 MY, 100% of 2021+ MY - The following detection thresholds apply: - When misfire percentage is > 5% in each 1,000 engine revolution increment - Threshold relief is possible for: - o All engine certified MD vehicles: < 2.0 x NMHC, CO, NOx standard or 0.03 g/bhp-hr PM emission impact (with data evaluation) - o Chassis Certified Passenger Cars, LD Trucks, MDPVs: Non-LEV III = 1.5 x NMHC/CO/NOx stds. or 2.0 x PM standard; LEV III = ^a - Misfire monitoring conditions – continuous monitoring as follows: - For Passenger Cars, LD Trucks, and Chassis Certified MDPVs – 2010 MY through 2021 MY, engine certified MDPVs – 2010 MY through 2018 MY, and all other vehicles not included in phase-in schedules below: - o Positive torque conditions up to 75% of peak torque with engine speed up to 75% rated max. speed, except region bounded by the following points: Positive torque line and engine speed of 50% of max., and engine torque of 5% of peak torque above positive torque line and engine speed 75% of max. - For Passenger Cars, LD Trucks, and Chassis Certified MDPVs – 20% of 2022 MY, 50% of 2023 MY, 100% of 2024+ MY; - o All positive torque engine speed conditions, except region bounded by: The positive torque line and engine speed of 50% of max. and 10% of peak torque above positive torque line and engine speed 100% of max.

^aRefer to Diesel Emission Thresholds.

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Conditions for malfunction in each monitor area for diesel vehicles (cont.)

Monitor area	Malfunction criteria
Particulate Matter System	• Incomplete regeneration • Missing substrate • Active/intrusive injection
Exhaust Gas Sensor Heater	• Current or voltage outside manufacturer specification (requires CARB thresholds approval)
Feedback Control	For: reductant injection, fuel system, exhaust gas sensors, boost pressure, EGR, NOx adsorber, PM system. • Monitoring of proper feedback control to diagnose: - Delayed entrance to feedback control - Failure or deterioration causes open loop or default operation - Feedback control adjustment at max. authority and unable to achieve target
Cooling System; Crank-case Ventilation; Comprehensive Components	Refer to OBD II requirements for ALL VEHICLES (top of CARD OBD II section).



US AND CALIFORNIA - CARB (AND EPA) OBD II

Conditions for malfunction in each monitor area for diesel vehicles (cont.)

Monitor area	Malfunction criteria (and/or system requirements)
Other Emission Related Components or Systems	(System requirements: Must request Executive Officer approval prior to introduction on a particular vehicle).
Exceptions to Monitoring Requirements	• Emissions Thresholds may be modified by Exec. Officer, dependent on upon most reliable monitoring method capabilities • PC/LDT SULEV II: Executive Officer shall approve malfunction criterion of 2.5 x Standard in lieu of 1.5 x Standard • Federal Bin 3 or 4: Use ULEV II NMOG & CO, with SULEV II NOx criteria • Disabling allowed (with CARB approval) for: ambient temperature < 20°F, altitude > 8,000 ft, vehicle speed > 82+ mph, fuel volume < 15% of capacity, battery voltage < 11V, battery voltage > manufacturer limit, during power take-off operation, or tire pressure default action • Chassis certification 2016+ MY MD Vehicles: as specified in applicable section, except: - NMHC Catalyst Conversion Efficiency: 1.75 x NMHC & NOx standard - Misfire: use MD engine certif. requirements
NMHC Converting Catalyst - Conversion Efficiency	(excluding downstream or PM filter for regeneration) • Chassis certification: Non-LEV III vehicles = 1.75 x NMHC standard; LEV III = ^a

^aRefer to Diesel Emission Thresholds.

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Conditions for malfunction in each monitor area for diesel vehicles (cont.)

Monitor area	Malfunction criteria
NMHC Converting Catalyst (cont.) - Other Aftertreatment Assistance Function	- Exotherm generation (PM filter regen. assistance): Catalyst unable to generate sufficient exotherm for regeneration - Feedgas constituency (SCR assistance): - to 2024 MY PC, LDT, MDV (chassis cert.): catalyst unable to generate sufficient exotherm for regeneration (exemption if no malfunction results in a) exceeding useful life standard b) increase in emissions of > 30%, of applicable NOx or NMOG+NOx standard) 2025+ MY: LEV III = Any applicable NMOG+NOx threshold; - Alternatively, if NMHC efficiency monitor is used to fulfil feedgas monitoring requirement, NOT required to implement a specific feed gas monitor - NMHC Conversion Downstream of PM Filter for use during regeneration: No detectable amount of NMHC conversion - Converter downstream of SCR system: no detectable amount of NMHC, CO, NOx, or PM conversion capability (Exemption if: Catalyst is included, monitored, and aged as part of SCR system OR Catalyst is NOT part of SCR system and exemption conditions above met)
NOx Converting Catalyst - Conversion Efficiency	Chassis Certification: Non-LEV III = 1.75 x std (NOx or NMHC); for LEV III = °

°Refer to Diesel Emission Thresholds.

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Conditions for malfunction in each monitor area for diesel vehicles (cont.)

Monitor area	Malfunction criteria
NOx Converting Catalyst - Selective Catalytic Reduction (SCR)	• Reductant delivery: (same emission thresholds as 'Conversion Efficiency' above) • For reductant other than engine fuel: - Insufficient reductant for proper operation - Improper reductant in reservoir/tank
NOx Converting Catalyst - Feedback Control	• Fails to begin control within manufacturer-defined time • Failure or deterioration causes open loop or default operation • Control maximum authority reached and cannot achieve control target



US AND CALIFORNIA - CARB (AND EPA) OBD II

Conditions for malfunction in each monitor area for diesel vehicles (non-LEV III)

Monitor area	LDV and MDV (Chassis Cert.) threshold					MDV (Engine Cert.) threshold				
	MY	NMHC	CO	NOx	PM	MY	NMHC	CO	NOx	PM
NOx Adsorber	2013+	1.75 x	–	1.75 x	–	2013+	2.0 x	–	+0.2	–
Exhaust Gas Sensor Performance – NOx and PM sensors – 2022+ MDV Engine Cert: NOx sensor activity	2013+	1.5 x	1.5 x	1.75 x	2.0 x	2013 – 2015	2.0 x	–	+0.3	–
		–	–	–	–	2016+	2.0 x	–	+0.2	0.03
EGR Low Flow, High Flow, Response – Cooler performance	2013+	1.5 x	1.5 x	1.5 x	2.0 x	2013+	2.0 x	2.0 x	+0.2	0.03
Boost Pressure Ctrl (under & over) – Variable Geometry Turbocharger (VGT) – Resp., Charge Air Undercool										
Cold start – Emission Reduction Strategy	Fault due to control strategy input error or output error (refer to gasoline section for general requirements). 20% of 2026, 50% of 2027, 100% of 2028+: compare inlet temp/energy to 1 st NOx reducing element to modeled to verify working as intended									
	to 2025 MY	1.5 x	1.5 x	1.5 x	2.0 x	2013+	2.0 x	2.0 x	+0.2	0.03

(If standard is given, unit is g/bhp-hr)

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Conditions for malfunction in each monitor area for diesel vehicles (non-LEV III) (cont.)

Monitor area	LDV and MDV (Chassis Cert.) threshold					MDV (Engine Cert.) threshold				
	MY	NMHC	CO	NOx	PM	MY	NMHC	CO	NOx	PM
Variable Valve Train Timing and/or Control (VVT) - Target Error - Slow Response	2013+	1.5 x	1.5 x	1.5 x	1.75 x	2013+	2.0 x	2.0 x	+0.2	0.03
Particulate Matter Filter	2013+	-	-	-	1.75 x	to 2023	2.0 x	2.0 x	-	0.03
						2024 - 2025	2.0 x	2.0 x	+0.2	0.03
						2026 - 2028 (Opt 1) 2029+	2.0 x	2.0 x	+0.2	0.02
						2026+ (Opt 2)	2.0 x	2.0 x	+0.2	0.02

(If standard is given, unit is g/bhp-hr)

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Conditions for malfunction in each monitor area for diesel vehicles (non-LEV III) (cont.)

Monitor area	LDV and MDV (Chassis Cert.) threshold					MDV (Engine Cert.) threshold				
	MY	NMHC	CO	NOx	PM	MY	NMHC	CO	NOx	PM
	Particulate matter filter system									
- Frequent Regeneration	2013+	1.5 x	1.5 x	1.5 x	-	2013+	2.0 x	-	+0.2	-
- NMHC Catalytic Conversion	2015+	1.75 x	-	-	-	2015-2021	2.0 x	-	-	-
						2022+	2.0 x	-	+0.2	-
	Exemption for no malfunction able to increase emissions by 30% (engine cert. MDVs) or 15% (all other vehicles) of full useful life standard AND does not exceed the full useful life standard									
- Feedgas monitoring	To 2024	Unable to generate feedgas for proper SCR operation. Exemption if no malfunction results in a) exceeding NOx (or NMOG+NOx) standard AND b) increase in emissions < 30%								
	2025 + LEV III	LEV III NMOG + NOx				2025 +	+ 0.2 NOx			
	Alternatively, if NMHC efficiency method is used, NOT required to implement specific feedgas monitor									
Aftertreatment Assistance Function	2010 + loss function (LEV III Proposal: Feedgas required 2015+)					2010 + loss function				

(If standard is given, unit is g/bhp-hr)

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Conditions for malfunction in each monitor area for diesel vehicles (non-LEV III) (cont.)

Monitor area	MY	LDV and MDV (Chassis Cert.) threshold				MDV (Eng. Cert.) threshold NOx Cert. > 0.50 g/bph-hr				MDV (Eng. Cert.) threshold NOx Cert. ≤ 0.50 g/bph-hr			
		NMHC	CO	NOx	PM	NMHC	CO	NOx	PM	NMHC	CO	NOx	PM
Fuel System Pressure Control	2013+	1.5 x	1.5 x	1.5 x	2.0 x	1.5 x	1.5 x	1.5 x	0.03	2.0 x	2.0 x	+0.2	0.03
Fuel System Injection Quantity/Timing	2013+	1.5 x	1.5 x	1.5 x	2.0 x	Same Fault Criteria as Fuel System Pressure Control							
Fuel Control System using Tolerance compensation features	2015+	Detect if compensation does not match (exemption for no malfunction able to increase emissions by 15% of full useful life standard AND does not exceed the full useful life standard)											
Downstream Exhaust Gas Sensor Performance A/F Sensors	2013+	1.5 x	1.5 x	1.75 x	2.0 x	2.5 x	2.5 x	2.5 x	0.05	2.0 x	2.0 x	+0.2	0.03
Upstream Exhaust Gas Sensor Performance A/F Sensors	2013+	1.5 x	1.5 x	1.5 x	2.0 x	1.5 x	1.5 x	1.5 x	0.03	2.0 x	2.0 x	+0.2	0.03
EGR Catalyst	2013+	No detectable amount of constituent oxidation (monitoring not required for no measurable emission impact under any reasonable driving condition)											
EGR Low Flow, High Flow, Response Cooler Performance	2013+	-	-	-	-	1.5 x	1.5 x	1.5 x	0.03	2.0 x	2.0 x	+0.2	0.03
Variable Valve Train Target Error Slow Response	2013+	-	-	-	-	1.5 x	1.5 x	1.5 x	0.03	2.0 x	2.0 x	+0.2	0.03

(If standard is given, unit is g/bhp-hr)

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Conditions for malfunction in each monitor area for diesel vehicles (LEV III)

Exhaust standards		Monitor thresholds (except catalyst) ^e			Aftertreatment monitor thresholds ^f			DPF filtering performance monitoring threshold				
Vehicle type	Vehicle emission category	NMOG+ NOx Mult.	CO Mult.	PM Mult.	NMOG+ NOx Mult.	CO Mult. ^a	PM Mult.	NMOG+ NOx Mult.	CO Mult. ^b	PM Mult.	PM (mg/mi)	
Passenger cars, Light- Duty Trucks and Chassis Certified MDPVs	LEV160 / ULEV125	1.50	1.50	2.0	1.75	1.50	2.0 ^a	1.50	1.50	N/A	To 2025 (and 2029 for Opt 1): 17.50 2026 + (Opt 2): 10.00 2029+ (Opt 1): 10.00	
	ULEV70 / ULEV50	2.00			2.00			2.00				
	SULEV30 / SULEV20 ^d	2.50	2.50		2.50	2.50		2.50				
MY 2016-18 Chassis Certified MDVs ^g	All MDV	1.50	1.50	2.0	1.75	N/A	N/A	N/A	N/A	1.75 ^b	17.50 ^c	
MY 2019+ Chassis Certified MDVs	MDV 8,500 to 10,000 lb GVWR			1.50 ^b or 2.0 ^c		1.5	1.5 ^b or 2.0 ^c	1.50	1.50	1.50	To 2028: 17.5 2029+: 14.0	
MY 2019+ Chassis Certified MDVs ^g	MDV 10,001 to 14,000 lb GVWR							1.50	1.50	1.50 ^b	17.50 ^c	

^a Applies to 2019 and subsequent MY.

^b Applies to vehicles not included in the phase-in of the PM standards set forth in Title 13, CCR section 1961.2 (a)(2)(B)2 and (a)(2)(D)3.

^c Applies to vehicles included in the phase-in of the PM standards set forth in Title 13, CCR section 1961.2(a)(2)(B)2 and (a)(2)(D)3.

^d Manufacturer shall use the 2.5 times NMOG + NOx multiplier for vehicles not using the provisions of

section (f) (17.1.7).

^e Applies to (f)(3.2.5). (f)(4)-(f)(7). (f)(9.2.2). (f)(12)-(f)(13).

^f Applies to (f)(1)-(f)(2). (f)(8). And (f)(9.2.4)(A).

^g Except MDPVs.

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PR OF CHINA - CHINA 6 OBD

China on-board diagnostics

China 6 OBD requirements (Regulation GB 18352.6) are based on CARB OBD II regulations with local updates, however certification is based on European emission cycle with OBD threshold defined on WLTC. Compared to Europe, China OBD threshold is NOx + NMHC while in Europe there is separately NOx and NMHC threshold.

List of monitoring function needed for gasoline:

- Catalyst Monitoring
- Heated Catalyst Monitoring
- Misfire Monitoring
- Evaporative System Monitoring
- Secondary Air System Monitoring
- Fuel System Monitoring
- Exhaust Gas Sensor Monitoring
- Exhaust Gas Recirculation (EGR) System Monitoring
- Positive Crankcase Ventilation (PCV) System Monitoring
- Engine Cooling System Monitoring
- Cold Start Emission Reduction Strategy Monitoring
- Variable Valve Timing (VVT) System Monitoring
- Gasoline Particulate Filter (GPF) Monitoring
- Comprehensive Component Monitoring

Gasoline China Specific monitoring different from CARB:

- 0.040" evaporative system leak monitor (0.020" detection not required, but optionally allowed)
- Asymmetric O₂ response monitor not required (only symmetric is required)
- Air Fuel Ratio Cylinder Imbalance monitor not required
- For cold start emission reduction strategy, the final delivered spark timing can be replaced with final commanded spark timing to detect the spark timing retard is correct
- The requirement of misfire reporting logic within the first 1,000 revolutions after engine start in CARB does not exist in China 6

OBD Threshold Limit (All Fuel)

Category	Class	CO	NMHC + NOx	PM
		g/km		
Type 1		1.900	0.260	0.012
Type 2	I	1.900	0.260	
	II	3.400	0.335	
	III	4.300	0.390	

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PR OF CHINA - CHINA 6 OBD

Diesel monitoring requirements:

Non-Methane Hydrocarbon (NMHC) Converting Catalyst Monitoring	Conversion Efficiency
	Catalyst System Aging and Monitoring
Oxides of Nitrogen (NOx) Converting Catalyst Monitoring	Conversion Efficiency
	Selective Catalytic Reduction (SCR) or Other Reductant Injection System Performance
	Catalyst System Aging and Monitoring
Misfire Monitoring	Minimum 5% of Misfire on single cylinder
	Based on 1,000 Rev.
	Multiple cylinder 50% on all engine firing event
	% Misfire exceeding OBD threshold
Fuel System Monitoring	Fuel Pressure Control
	Feedback control

Exhaust Gas Sensor Monitoring	Air-fuel Ratio Sensors
	NOx and PM sensors
	Sensor Heaters
Exhaust Gas Recirculation (EGR) System Monitoring	Low Flow
	High Flow
	Slow Response
	Feedback control
	EGR Cooler Performance
Boost Pressure Control System Monitoring	Under Boost
	Over Boost
	Slow Response
	Charge Air Undercooling
	Feedback Control
NOx Adsorber Monitoring	NOx adsorber capability
	Fuel injection capability to achieve NOx desorption
	Feedback Control

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(cont.)

Particulate Matter (PM) Filter Monitoring	Filtering Performance
	Frequent Regeneration
	Incomplete Regeneration
	Missing Substrate
	Active Injection
	Feedback Control
Engine Cooling System Monitoring	Thermostat
	ECT Sensor

Cold Start Emission Reduction Strategy Monitoring	Commanded object does not properly respond to the commanded action
	Vehicle's emissions to exceed the OBD thresholds
Variable Valve Timing (VVT) System Monitoring	Target Error
	Slow Response
Comprehensive Component Monitoring	Input Components
	Output Components/Systems
	Hybrid Components

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PR OF CHINA - CHINA 6 OBD

Diesel monitoring requirements not required in CN6 compared to CARB OBD II:

Monitor area	Condition for malfunction (required in CARB but not in CN6)
FIE	Injection Quantity, Pilot and Total Injection Timing Comprehensive Component C3I
EGR	EGR Catalyst Performance
MISFIRE	Intermittent Misfire (5%) Full Range
NMHC	Non-sufficient exotherm Non-sufficient feedgas for SCR
PM Filter	NMHC Conversion Feedgas generation
Coolant	Temperature drop

IUPR(m) requirement CN6

The same calculation is used as in EU.

Ratio(m) = Numerator (m) / General denominator (m):

- Numerator incrementation based on monitoring completion
- Denominator condition based on standard driving conditions

OBD monitors	Minimum IUPR
Catalyst, O ₂ Sensors EGR, VVT and all others monitors	0.336
EVAP Purge Flow	0.336
EVAP Leak 1 mm	0.260
EVAP Leak 0.5 mm	0.100
EVAP High load purge	0.100
Secondary Air, PCV, GPF cold start, CSERS, Cooling Systems, Comprehensive Component Monitoring	0.100
Specific Hybrid Monitors	0.100

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India OBD - BS VI-1 OBD and BS VI-2 OBD from AIS-137 (part 3)

Since 2010, all vehicles (except LPG or CNG-fueled vehicles and those > 3,500 kg GVW until 2013) shall be equipped with OBD systems. These systems must identify failure areas if resulting in emissions above the limits given in the following tables.

OBD thresholds for BS VI vehicles are equivalent to Euro 6-1 applied as 1st phase (1 April 2020) and to Euro 6-2 applied as 2nd phase (1 April 2023) but with NICD test cycle.

Thresholds in 1st phase AIS 137 BS VI - OBD - I (1 April 2020)

Vehicle			CO		NMHC		NOx		PM	
Category	Class	Reference mass (RM) - (kg)	mg/km							
			PI	CI	PI	CI	PI	CI	PI ^a	CI
M (M ₁ & M ₂)	–	All	1,900	1,750	170	290	150	180	25	25
N ₁	I	RM ≤ 1,305	1,900	1,750	170	290	150	180	25	25
	II	1,305 < RM ≤ 1,760	3,400	2,200	225	320	190	220	25	25
	III	RM > 1,760	4,300	2,500	270	350	210	280	30	30
N ₂	–	All	4,300	2,500	270	350	210	280	30	30

The regulations apply to categories M₁, N₁ Class I, N₁ Class II, N₁ Class III, and N₂ with a reference mass not exceeding 2,610 kg. If requested by manufacturers, it may be extended to M₁, M₂, N₁ and N₂ type approval vehicles with a reference mass not exceeding 2,840 kg which meet the conditions established by the regulation.

Starting from 1 April 2023, according to the requirements specified in AIS-137, BS VI IUPRM shall be greater or equal to 0.1 for all monitors M.

Thresholds in 2nd phase AIS 137 BS VI - OBD - II (1 April 2023)

Vehicle			CO		NMHC		NOx		PM	
Category	Class	Reference mass (RM) – (kg)	mg/km							
			PI	CI	PI	CI	PI	CI	PI ^a	CI
M (M ₁ & M ₂)	–	All	1,900	1,750	170	290	90	140	12	12
N ₁	I	RM ≤ 1,305	1,900	1,750	170	290	90	140	12	12
	II	1,305 < RM ≤ 1,760	3,400	2,200	225	320	110	180	12	12
	III	RM > 1,760	4,300	2,500	270	350	120	220	12	12
N ₂	–	All	4,300	2,500	270	350	120	220	12	12

^a Applies only to direct injection positive ignition engines.

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India on-board diagnostics - AIS 175 BS VI - OBD stage III (1 April 2025)

Introduction of iWLTP and RDE Test Cycle.

DPF regen efficiency and clogging monitoring required.

SCR conversion efficiency monitoring required.

NOx Sensor required if SCR or NOx Trap present.

EVAP Leak detection ≥ 0.5 mm.

PM/PN monitoring if DPF present.

Misfire Detection with adapted threshold for PN.

Catalyst Temperature monitoring broaden with PN/NOx impact.



JAPAN

Japan on-board diagnostics (J-OBDII)

J-OBDII is applied to the following vehicle configuration.

- Gasoline and LPG fuel
- Vehicle weight less than 3.5t
- Max. passenger less than 10

OBD Emission threshold is defined as follows. Test cycle is combined JC08 mode.

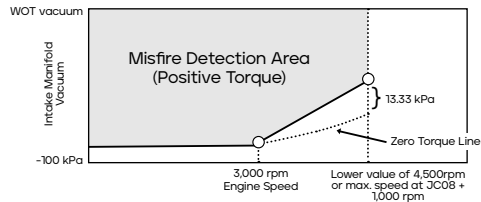
- $0.25 \times \text{JC08_Cold} + 0.75 \times \text{JC08_Hot}$

	Passenger car	Light commercial vehicle	Medium commercial vehicle
CO (g/km)	4.06	12.46	14.28
NMHC (g/km)	0.28	0.28	0.28
NOx (g/km)	0.30	0.30	0.30

Misfire detection area is defined as in the figure below.

Threshold for functional detection can be defined as follows.

- If emission failing misfire rate is less than 1%, 1% is defined as functional detection threshold
- If catalyst damaging misfire rate is less than 5%, 5% is defined as functional detection threshold





JAPAN

Relevant monitor areas

Monitor area	Circuit continuity	Functional detection	Emission threshold
Catalyst converter			x
Engine misfire		x	x
Oxygen sensor deterioration	x		x
EGR System		x	x
Fuel system		x	x
Exhaust Secondary Air System		x	x
Variable Valvetrain System		x	x
EVAP System	x	x	
Any Other Emission Related Components or Systems Connecting to ECU	x		

Japan on-board diagnostics scope and implementation dates

1. Gasoline or LPG vehicles > 3.5t (excluding passenger capacity ≤ 9 people): J-OBD I
2. Diesel vehicles > 3.5t (excluding passenger capacity ≤ 9 people): J-OBD II
3. Gasoline, LPG or diesel vehicles ≤ 3.5t, or passenger capacity ≤ 9 people: WLTP-OBD
 - Applied from 2021 Oct for new vehicles
 - Applied from 2022 Oct for imported vehicles
4. Vehicles using fuel other than gasoline, LPG, or diesel: separately determined as necessary



SOUTH KOREA

South Korea on-board diagnostics

Regulation on Testing and Inspection Procedures for Manufactured Vehicles (Appendix 15-2) Special Provisions on Operational Criteria for On-Board Diagnostic (OBD) Systems in Gasoline Passenger Vehicles (Related to Article 5, Paragraph 1).

Category	Implementation	Thresholds in g/km			
		CO	NMHC	NO _x	PM ^a
Operational Criteria (I) - EURO 5 OBD	-	1.9	0.25	0.3	0.05
Operational Criteria (II) - EURO 6 OBD	TA - 31 Aug 2017 FR - 31 Aug 2018	1.9	0.17	0.15	0.025
	TA - 1 Sep 2017 FR - 1 Sep 2018	1.9	0.17	0.09	0.012

^a For GDI engines only.

^b TA: 1 September 2011 - / FR: 1 January 2014.

Monitoring area

Catalyst conversion efficiency against HC

Catalyst conversion efficiency against NO_x^b

Misfire detection

O₂ sensor deterioration

Emission - related components

Disconnection or short-circuit of sensors and other emission-related components

Disconnection or short-circuit of the electronic purge valve

- Korean OBD regulations are based on EURO OBD standards
- Technical requirements are similar to UN Reg 83. Annex 11
- Complying with ISO 15031-5 standards for the access to OBD information

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SOUTH KOREA

South Korea on-board diagnostics

Regulation on Testing and Inspection Procedures for Manufactured Vehicles (Appendix 16) Operational Criteria and Performance. Verification Test Methods for On-Board Diagnostic (OBD) Systems in Diesel Passenger Vehicles (Related to Article 5, Paragraph 2).

Category	Implementation	Thresholds in g/km			
		CO	HC	NOx	PM
PC 2.5t max.	TA - 1 Jan 2006 - 31 Dec 2011 FR - 31 Dec 2013	3.2	0.4	1.2	0.18
PC all	TA - 1 Jan 2012 - FR - 1 Jan 2014 -	1.9	0.32 ^a	0.54 (0.24) ^b	0.05
PC all	TA - 1 Sep 2014 - FR - 1 Sep 2015 -	1.75	0.29	0.18	0.025
PC ^c all	TA - 31 Aug 2017 - FR - 1 Sep 2018 -	1.75	0.29	0.14	0.012

^a HC refers to NMHC.

^b Applies to diesel vehicles subject to the emission limits for Type 2 low-emission vehicles or equivalent standards, as specified in Annex 2, Item 3 of the Enforcement Rules of the Special Act on Metropolitan Air Quality Improvement.

^c Vehicle manufacturer must select either NEDC or WLTP for the performance verification test of the emission OBD system.

Monitoring area

Degradation of catalytic converter efficiency (if equipped)

Malfunction or integrity issues of the diesel particulate filter (if equipped)

Electrical circuit disconnection or short circuit, and complete malfunction of fuel injection system or electronic actuators for fuel quantity/timing

Malfunction of emission-related or powertrain components connected to the engine control unit that causes emissions to exceed the threshold

Electrical circuit disconnection or short circuit of powertrain components related to emissions and connected to the computer

Malfunction or efficiency degradation of the EGR system

Malfunction or efficiency degradation of NOx reduction after-treatment systems using additives and their supply systems

Malfunction or efficiency degradation of NOx reduction after-treatment systems not using additives

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SOUTH KOREA

South Korea on-board diagnostics

In Use Performance Ratio monitoring (IUPR)

IUPR_M indicates how often a specific monitor is operating relative to vehicle operation:

$$\text{IUPR}_M = \text{Monitoring Frequency} / \text{Driving Frequency}$$

- Monitoring frequency is the number of times the OBD system completes monitoring of the component under conditions defined by the manufacturer
- Driving frequency indicates how many times the vehicle has been operated under in-use conditions

Category	Implementation	IUPR ^{a,b,c}	Monitoring items
Gasoline	TA - 31 Aug 2014 FR - 31 Aug 2015	0.1	
	TA - 1 Sep 2014 - FR - 1 Sep 2015 -	0.260	Secondary air, Cold start related components
		0.520	Evaporative purge control system
		0.336	Others
Diesel PC	TA - 31 Aug 2014 FR - 31 Aug 2015	0.1	
	TA - 1 Sep 2014 - FR - 1 Sep 2015 -	0.336	

^a If multiple monitors operate within a single system, calculate all indices individually.

^b The diagnostic tool must display the monitor with the lowest IUPR_M.

^c If multiple monitors share the same lowest IUPR_M, the one with the highest Driving frequency should be shown.



BRAZIL

Brazil on-board diagnostics development of OBD thresholds over time

	Requirements	Implementation	Vehicle mass	OBD emissions thresholds (g/km)				
				THC ^a	NMHC ^b	CO	NOx	PM
OBDBr-2	Continuity monitoring for main actuators and sensors Misfire, O ₂ response, catalyst monitoring diagnostics. O ₂ response and catalyst monitoring required only in % ethanol ranges of 19-30% and 90-100% No Fuel system diagnostics	CY 2014 - 2016	PC	0.75	0.3	4.11	0.75	-
			LDT ≤ 1,700 kg	0.75	0.3	4.11	0.75	-
			LDT > 1,700 kg	1.25	0.5	8.22	1.5	-
OBDBr-2+	O ₂ response and catalyst monitoring required in all % ethanol ranges New CO limit	CY 2018 onwards	PC	0.75	0.3	3.0	0.75	-
			LDT ≤ 1,700 kg	0.75	0.3	3.0	0.75	-
			LDT > 1,700 kg	1.25	0.5	6.0	1.5	-
OBDBr-D	OBD Diesel for light passenger vehicle and light commercial vehicle ≤ 3,856 kg (normative instruction Nr 5, 6 Feb 2013)	CY 2015 onwards	PC	-	0.3	2.4	0.3	0.3
			LCV ≤ 1,700 kg	-	0.3	2.4	0.3	0.3
			LCV > 1,700 kg	-	0.35	3.2	1.0	0.4

OBDBr-1: Continuity monitoring only, for main actuators and sensors.

^a THC for LPG vehicles.

^b NMHC for positive ignition vehicles except LPG.

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BRAZIL

Brazil on-board diagnostics (cont.)

	Requirements	Implementation	Vehicle mass	OBD emissions monitor thresholds (mg/km) ^d			OBD emissions catalyst monitor thresholds (mg/km)
				NMOG + NOx	CO NMHC ^b	PM ^b	NMOG + NOx
OBDBr-3 ^a PROCONVE L7	Unburned ethanol is not allowed to be deducted. Introduce NMOG + NOx Calculation. ^c 160,000 km durability. Fault codes, start dates and respective repairs must remain recorded for a minimum period of 400 consecutive days. ^e	January 2022 onwards	Light-duty passenger	360	2,000	36	480
			Light-duty commercial and off-road	630	2,500	36	840

^a OBDBr3, has as reference the provisions of CFR Title 40 Part 86 §86.1806 DIAGNOSTICS ON BOARD. Until the regulation of the OBD Br3 system is finalized, vehicles of the Phases PROCONVE L7 and L8 must comply with the requirements of the OBD Br2+ system established in Resolution CONAMA 354/2004.

^b Only applicable for GDI engines.

^c NMOG + NOx calculation based on CFR40.

^d Monitor threshold except catalyst.

^e Must use the PID Parameter Identifier 0x93.

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BRAZIL

Brazil on-board diagnostics (cont.)

	Requirements	Implementation	Vehicle mass	Level	OBD emissions monitor thresholds ^d			
					NMOG (mg/km)	NOx (mg/km)	CO (mg/km)	PM (mg/km) ^b
OBDBr-3 ^a PROCONVE L8	Unburned ethanol is not allowed to be deducted. Introduce NMOG + NOx Calculation. ^c 160,000 km durability. Fault codes, start dates and respective repairs must remain recorded for a minimum period of 400 consecutive days. ^e	January 2025 onwards	DIESEL Light-duty commercial vehicles	320	300	600	2,500	60
				280	290	520	2,500	60
				250	280	460	2,500	60
				220	270	405	2,000	30
				200	260	370	2,000	30
				170	250	310	2,000	27
			VLC > 1,700 Kg	140	240	255	2,000	18
				110	230	200	2,000	18
			VLP / VLC ≤ 1,700 kg	80	210	150	2,000	18
				70	180	135	1,500	18
				60	150	120	1,500	18
				50	120	105	1,500	18
				40	90	90	1,250	18
				30	70	65	1,250	12
				20	50	40	1,000	12

^aOBDBr3, has as reference the provisions of CFR Title 40 Part 86 §86.1806 DIAGNOSTICS ON BOARD. Until the regulation of the OBD Br3 system is finalized, vehicles of the Phases PROCONVE L7 and L8 must comply with the requirements of the OBD Br2+ system established in Resolution CONAMA 354/2004.

^bOnly applicable for GDI engines.

^cNMOG + NOx calculation based on CFR40.

^dMonitor threshold except catalyst.

^eIn addition to the PID Parameter Identifier 0x93, it must report the permanent fault codes (PDT) with storage of at least four fault codes that activated the LIM, as provided for in the US/California regulation CARB1968.2, and the PIDs 0x30 and PID 0x31 defined by international standards ISO 15031-5 and SAE J1979, and the technical requirements will be described in a Normative Instruction to be published by IBAMA.

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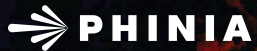
BRAZIL

Brazil on-board diagnostics - OBDBr-3^a PROCONVE L7 diesel vehicles

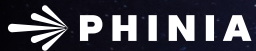
Requirements	Implementation	Vehicle mass	OBD emissions monitor thresholds (mg/km)			
			NMOG	NOx	CO	PM
The application of K _i Factor is not necessary.	January 2022 onwards	Light-duty passenger	160	200	2,000	36
		Light-duty commercial and off-road	300	600	2,500	60

^a Only for diesel OBDBr-3 PROCONVE L7 applications.

For diesel, OBDBr-3 PROCONVE L8 applications are in development at IBAMA.



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EUROPEAN UNION - EURO 6 AND 7 EVAPORATIVE EMISSIONS

Emission calculation and limit values

Evaporative emission calculation (from Euro 6d) = $M_{HS} + M_{D1} + M_{D2} + 2xPF$

($M_{D2} + 2xPF$ added, change from NEDC to WLTP)

Limit values:

Euro 6: 2.0 g / test

Euro 7 (from 28 November 2026): 1.5 g / test

Evaporative emissions test procedures

Test procedures follow UN/ECE R154 / GTR19.

Tank permeability factor (PF) is determined according to the following procedure:

Procedure for permeability factor

Tank PF procedure
Fill the tank to 40±2 per cent of its nominal capacity with reference fuel
Soak for 3 weeks at 40°C±2°C
Drain and fill the tank to 40% of its nominal capacity with reference fuel
HC _{3w} : Measurement of HC in the same conditions as for the 1 st day of diurnal emission test:
Soak for the remaining 17 weeks at 40°C±2°C
Drain and fill the tank to 40% of its nominal capacity with reference fuel
HC _{20w} : Measurement of HC in the same conditions as for the 1 st day of diurnal emission test:
Permeability Factor PF = HC _{20w} - HC _{3w}

A manufacturer using multilayer tanks or metal tanks may choose an Assigned Permeability Factor: 120 mg/day.



EUROPEAN UNION - EURO 6 AND 7 EVAPORATIVE EMISSIONS

Evaporative emissions test procedures (UN/ECE R154 / GTR19)

Common initial sequence	
Drain fuel and fill to 40% with test fuel	
Soak 12-36 hours $23 \pm 3^\circ\text{C}$ ambient	
Preconditioning drive $23 \pm 3^\circ\text{C}$ ambient ^a	

GTR Test sequence for non sealed fuel tank: Euro 6c/d	
Drain fuel and fill to 40% with test fuel	
Soak for 6-36 hours at 23°C	
Charge OVC-HEV ^c REESS ^d	OR Load canister after Bench ageing connecting to car to 2 g breakthrough

Common final sequence	
Dynamometer test $23 \pm 3^\circ\text{C}$ ambient	
M_{15} : Hot soak test $60\text{min} \pm 0.5\text{min}$ at $23-31^\circ\text{C}$ ambient	
Soak for 6-36 hours at $20 \pm 2^\circ\text{C}$ ambient	
M_{D1} : 1 st day diurnal 24 h in VT SHED, cycle from $20-35-20^\circ\text{C}$	
M_{D2} : 2 nd day diurnal 24 h in VT SHED, cycle from $20-35-20^\circ\text{C}$	

Alternative sequence for sealed fuel tanks, stand-alone hot soak and diurnals	
Soak for 6-36 hours at 23°C	
Charge OVC-HEV ^c REESS ^d	OR Load aged canister to 2 g breakthrough
	OR Canister purge 85% fuel consumption equivalent
	OR Canister loading with puff loss simulated mass

Alternative sequence for sealed fuel tanks continuous and sealed fuel tanks stand-alone puff	
Fuel drain and refill to 15%	
Soak for 6-36 hours at 20°C : · fuel tank pressure relief · load aged canister · canister purge	
Preparation of canister depressurisation puff loss loading (11-hour temperature cycle)	
Puff loss loading and measurement	OR Puff loss overflow
Soak for 6-36 hours at 23°C (Charge OVC-HEV)	
Fuel drain and refill to 40%	
Soak for 6-36 hours at 20°C	
Fuel tank depressurisation with canister disconnected	

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EUROPEAN UNION - EURO 3-4-5-6C EVAPORATIVE EMISSIONS

Emission calculation and limit values

Evaporative emission calculation = diurnal test + hot soak

Limit values Euro 3-4-5-6c: 2.0 g / test

Evaporative emissions test procedure Euro 3-4-5-6c Regulation 715/2007/EC, Regulation 692/2008/EC Annex VI, UN/ECE Regulation No. 88 Annex 7.

^a New Pre-conditioning drive and Driving cycle by class of vehicles defined:

Class 1: 2x Low-Medium-Low. Class 2 & 3: Low-Medium-High-Medium.

^b From Euro 6e: Low-Medium-High-Extra high.

^c Off-Vehicle Charging Hybrid Electric Vehicle.

^d Rechargeable Electric Energy Storage System.

Test sequence for Euro 3-4-5-6c

Test sequence: Euro 3-4-5-6c, TA 1/2000
Fill to 40% with test fuel
Canister loading: Repeated diurnal heat builds or butane/N ₂ loading to 2 g breakthrough
Drain tank, fill to 40% with test fuel
Preconditioning drive at 20-30°C: 1 ECE+2 EUDC cycles
Soak 12-36 hours at 20-30°C ambient
Exhaust test ECE+EUDC at 20-30°C
Evap conditioning drive Urban cycle max. 2 minutes later
Hot soak test 1 hour at 20-30°C ambient
Soak 6-36 hours (min 6 h at 20±2°C ambient)
Real time diurnal test 1 heat build in 24 h in VT SHED, cycle from 20-35°C, $\mu T=15K$

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US AND CALIFORNIA

CARB LEV III limit values (enhanced evaporative emissions, also adopted by EPA Tier 3)

- Requires expanding the use of existing zero-evap technology to vehicle classes not previously covered
- Two options are provided for complying with total hydrocarbon evaporative emissions from MY 2015 onwards

Option 1 (in practice not used)				Option 2				
Vehicle type (lbs GVWR)	3-day diurnal + hot soak and 2-day diurnal + hot soak		Running loss (g/mile)	Vehicle type (lbs GVWR)		Highest whole vehicle diurnal + hot soak (g/test)	Canister bleed (g/test)	Running loss (g/mile)
	Whole vehicle (g/test)	Fuel only (g/test)						
Passenger cars	0.35	0.0	0.05	Passenger cars		0.3	0.02	0.05
LD trucks ≤ 6,000 lbs	0.50			LD trucks ≤ 6,000 lbs	0 - 3,750 lbs LVW			
					3,750 - 5,750 lbs LVW			
LD trucks 6,000 - 8,500 lbs	0.75			LD trucks 6,000 - 8,500 lbs		0.5		

- Implementation schedule: 2015-2017: min. average of previous 3 models per year PZEVs. 2018-2019 60%, 2020-2021 80%, 2022 100%
- Eliminate testing with MTBE fuel, require testing with E10 for LEV III and all evaporative certifications from 2020
- Extend applicability of ORVR requirement to complete vehicles up through 14,000 lbs GVWR inclusive (option to use E10 fuel for testing in lieu of federal certification fuel)
- Outstanding issues: implementation of leak test (permissible orifice 0.01-0.02 inch to complete the current 2-day or 3-day diurnal test procedure sequence)
- Useful life shall be 15 years or 150,000 mi, whichever occurs first

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US AND CALIFORNIA

Test sequence

Temperature	3-day diurnal	Supplemental 2-day diurnal
68–86°F	Fuel drain / fill	Fuel drain / fill
	6 h minimum soak	6 h minimum soak
	Preconditioning: 1 EPA II. Fuel drain/fill. 12–36 h soak. Canister purge: 300 BV at 0.8 dfm with 25–75 g/lb dry air Canister load: 1.5 x WC at 15 g butane/h with 50/50 butane/N ₂ mix	Preconditioning: 1 EPA II. Fuel drain/fill. 12–36 h soak. Canister load: Load to 2 g break-through at 40 g butane/h with 50/50 butane/N ₂ mix
	Exhaust test: EPA III	Exhaust test: EPA III
EPA: 90–100°F CARB: 100–110°F	1–6 h soak Running loss test: EPA II, 2x NYCC, EPA II	Not required
	1 h hot soak test (EPA 95 / CARB 105°F)	1 h hot soak test (68–86°F)
	Stabilize temperature: 6–36 h (EPA 72 / CARB 65°F)	Stabilize temperature: 6–36 h (EPA 72 / CARB 65°F)
	Diurnal emission test 3 heat builds in 72 h EPA cycle 72–96°F, CARB cycle 65–105°F	Diurnal emission test 2 heat builds in 48 h EPA cycle 72–96°F, CARB cycle 65–105°F

Note: Vehicle certification requires the 3-day diurnal, in-use vehicles the supplemental 2-day diurnal test.

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Additional requirements

For 2012 and subsequent model year off-vehicle charge capable hybrid equipped with a non-integrated refueling canister only system.

- The canister should be loaded using fuel-tank-refill method described under "refueling event" section of ORVR procedure (see page 102)
- For hybrid vehicles, battery state-of-charge setting prior to the exhaust test shall be at the level minimum operation of engine

Running Losses:

- Until Tier 3 / LEV III regulations maximum limit was 0.05 g/mile
- In 2024+ Tier 4 / LEV IV reduced this limit to 0.01 g/mile

Advanced Clean Cars II (ACC II)

- As part of ACC II, CARB introduced amended emissions standards including more stringent evaporative requirements for hybrid vehicles
- Due to the revocation of the ACC II waiver in June 2025, implementation of these amendments is on hold

Further EPA Tier 3 requirements

Tier 3 began in 2018, same phase-in percentages as CARB LEV III Harmonization of requirements with CARB LEV III.

- OBD detection of leak greater than 0.02 inch required
- Phase-in vehicles will be tested with E15. E10 as option available in 2017
- After 2020, all test fuel should be EPA (E15) certification fuel
- Requirements do not include rig test in the regulation, but certification will be accepted for PZEV in 2017 and beyond until 2019
- Useful life extended to 150,000 mi
- OBD detection of leak greater than approx. 0.01 inch for pressurized fuel systems

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US AND CALIFORNIA

On-board refuelling vapor recovery (ORVR) standards

ORVR standard

- HC standard: 0.2 g/gallon (0.053 g/L)
- Applicable in all US Federal States. CARB adopted EPA regulation phase-in with 40/80/100% over 3 years

Passenger cars	MY 1998-2000
LDT ≤ 6,000 lbs GVW	MY 2001-2003
LDT > 6,000 lbs GVW	MY 2004-2006
- No changes to ORVR procedures for CARB LEV II and EPA Tier 2
- Measurement of emissions that escape from the vehicle during a refueling event. Stand-alone test in addition to enhanced EVAP tests
- Fuel used: US Certification fuel 8.7-9.2 RVP

CARB LEV III amendment

- California certification fuel E10 (7 psi RVP) may be alternatively used for MY 2015 onwards
- If using California certification fuel, the fuel shall be dispensed at a temperature of $79 \pm 1.5^\circ\text{F}$ ($26.1 \pm 0.8^\circ\text{C}$) and at a dispensing rate of 9.8 ± 0.3 gal/min (37 ± 1.1 l/min)

ORVR test procedures and limit

Vehicle preconditioning	• Fuel drain and fill to 40% • 6 h min. soak at $68-86^\circ\text{F}$ ($20-30^\circ\text{C}$) • 1x EPA II preconditioning drive
Canister preconditioning	• Fuel drain and fill to 40% • 12-36 h soak • Load canister with HC vapors until 2 g breakthrough at 40 g/h 50% butane/N_2 • Exhaust test: EPA III (recording emissions) • 0-1 h soak at $68-86^\circ\text{F}$ ($20-30^\circ\text{C}$) • Canister purge drive at $68-86^\circ\text{F}$: EPA II, 2x NYCC, EPA II
Refueling event	• Disconnect canister(s) • Fuel drain and fill to 10% • 6-24 h soak at $80 \pm 3^\circ\text{F}$ (27°C) • Reconnect canister(s) • Dispense fuel at 10 gal/min until automatic shut-off. If < 85% of total tank capacity is dispensed, continue auto-refueling until fuel dispensed is $\geq 85\%$. Administrator may use 4 gal/min rate (15 l/min) • Dispense fuel temperature: $67 \pm 1.5^\circ\text{F}$ (19°C)
HC standard: 0.2 g/gallon (0.053 g/L)	



US AND CALIFORNIA

CARB LEV II and EPA Tier 2 test conditions (enhanced evaporative emissions)

EPA and California accept certification data generated using the other agency's test procedure.

EPA evaporative emissions requirements

- Harmonizes federal limits with CARB LEV II requirements:
 - 3-day diurnal = 0.5 g/test for LDV
 - Supplemental 2-day = 0.85 g/test for LDV
 - LLDT / HLDT / MDPV have less stringent requirements
- CARB LEV II certification data to be used for EPA certification without prior approval
- Implemented in MY 2009 for LDV/LLDT and MY 2010 for HLDT/MDPV. Alternate phase-in for FFV (flex fuel vehicles) when operating on non-gasoline

Further CARB LEV II requirements

- Useful life for standards extended to 150,000 mi or 15 years
- 1.75x higher in-use standard for 3 model years for LEV II families introduced prior to 2007

- Optional "Zero-Evap" standard is available to earn NMOG credits or partial ZEV credits, 0.35 g/test for hot soak + highest diurnal (2 or 3 days) and 0.0 g (< 0.054 g) from fuel system

Further EPA Tier 2 requirements

- Useful life for standards extended to 120,000 mi
- Ethanol and HEV/ZEV vehicles regulated for the first time

Tier 2 and LEV II test conditions

	EPA Enhanced & Tier 2	CARB Enhanced & LEV II
Test temperature	95±5°F	105±5°F
Fuel	9 psi RVP, 7.8 psi for altitude testing	7 psi RVP
Phase-in	Enhanced: 1996 - 1999: 20/40/90/100% Tier 2: 2004 - 2007: 25/50/75/100%	Enhanced: 1995 - 1998: 10/30/50/100% Tier 2: 2004 - 2006: 40/80/100%

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PR OF CHINA - EVAPORATIVE EMISSIONS LIMITS AND TEST CONDITIONS

China 6 evaporative emissions requirements

- New gasoline vehicles up to and including China 5 must meet an evaporative emission limit of 2 g/test (SHED)
- China V CoP for canister: measured BWC & volume no less than 0.9 of declared value: Conformity of in-use < 2 g/day required for useful life
- Nationwide implementation light-duty 1 July 2020 (China 6a)
- Leak detection requirement: orifice detection size 0.5 to 1 mm

Type IV diurnal emission test procedure based on CARB test procedure

- WLTC preconditioning drive cycle, Type I: Low-Medium-High-High
- Preconditioning test requirements for NOVC and OVC
- Temperature soak and driving at $38 \pm 2^\circ\text{C}$ with connected canister
- Hot Soak test at initial Temperature $= 38 \pm 2^\circ\text{C}$; (range $33\text{--}41^\circ\text{C}$)
- SHED Temperature profile $68\text{--}95^\circ\text{F}$ ($20\text{--}35^\circ\text{C}$)
- China Fuel E0 56–60 kPa
- Conformity of Production (CoP) for Canister and Vehicle: Canister measured BWC & volume > 0.9 of declared value; Vehicle emission < 1.1 times of limit value

- Test procedure for Non-Integrated Refueling Canister Only (NIRCO) (tank drain and refill with disconnected canister)
- Emission calculation: diurnal (higher of 25 or 48 hour)+ hot soak
- Deterioration Factor (DF) defined for diurnal emission 0.06 g/day

China VI Type IV Diurnal emission limits incl. hot soak and DF

Stage	Vehicle category	Evaporative limit g/test (SHED)
CN6	Type 1	0.70
	Type 2 Cl. I	0.70
	Type 2 Cl. II	0.90
	Type 2 Cl. III	1.20

China V/VI Type VII ORVR requirements

- Type VII test ORVR limit < 0.05 g/L based on CARB test procedure
- DF defined for ORVR emission 0.01 g/L
- Test procedure for NIRCO (tank 95% fill and tank drain and refill 10% refill with disconnected canister)



Evaporative emissions requirements

Gasoline vehicles have to meet an evaporative (SHED) limit of 2 g/test since 2000.

Test conditions follow Euro standards:

- Current BS6 standard is equivalent to Euro 5 (1 day diurnal with 2.0 g/test limit)
 - The current certification fuel must now be E20
- Government of India has notified a Phase 3 of BS6, which will implement the WLTP drive cycle and GTR-19 from 1 April 2027. This will include adoption of test procedures under AIS-175, which incorporate UN GTR-19 for evaporative emissions (2-day diurnal, 2.0 g/test limit)
- BS7 discussions are in initial stages
- There are also discussions to move to E27



JAPAN - EVAPORATIVE EMISSIONS LIMITS AND TEST CONDITIONS

Evaporative Emissions (until 2020)

Running	4 x JC08
Hot Soak Loss (HSL)	1 hr SHED at $27 \pm 4^{\circ}\text{C}$
Diurnal Breathing	1 heat build in 24 hrs
Loss (DBL)	Cycle from 20°C - 35°C
Emission standard	$\text{HSL} + \text{DBL} \leq 2 \text{ g/test}$

New Evaporative Emissions (2020 and later)

Currently following GTR 19 (equivalent to Euro 6d)

Running	WLTC (Low, Medium, High, Medium)
Hot Soak Loss (HSL)	1 hr SHED at $27 \pm 4^{\circ}\text{C}$
Diurnal Breathing	2 heat build in 48 hrs
Loss (DBL)	Cycle from 20°C - 35°C
Emission standard	$\text{HSL} + \text{DBL}_{1^{\text{st}}\text{Day}} + \text{DBL}_{2^{\text{nd}}\text{Day}} + 2 \times \text{PF} \leq 2 \text{ g/test}$



SOUTH KOREA

South Korea

KLEV2 until 2016: limit 0.35 g/test (2 day diurnal).

KLEV3 from 2016:

- Limit 0.35 g/test (2 day diurnal)
- Leak detection requirements: orifice detection size 1.0 mm



BRAZIL

Evaporative requirement Proconve-L6 (past)

Evaporative requirement (E22/E61/E100) = 1.5 g/test during 24 hours SHED.

Evaporative requirement Proconve-L7 (since 1 January 2022) and L8 (since January 2025)

1. Evaporative requirement (E22/E61/E100) $\leq$ 0.5 g/test during 48 hours SHED;
2. Onboard Refueling Vapor Recovery requirement (ORVR) $\leq$ 50 mg/L refueling;

Test procedures based on CFR86 (US Federal Regulations, volume 40, part 86).

Leak detection requirement starting with L8: orifice detection size 2.286 mm (0.09").



EVERYTHING WE DO REVOLVES AROUND YOU. WE DEVELOP PREMIUM FUEL SYSTEMS AND ELECTRICAL SYSTEMS TO KEEP YOUR INTERNAL COMBUSTION ENGINES MORE EFFICIENT TODAY, WHILE INVESTING IN TECHNOLOGIES TO HELP BUILD A CLEANER TOMORROW.



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EUROPEAN UNION

EU regulation 2017/1151 - unleaded gasoline test fuel: petrol 95 RON E10

Parameter	Unit	Limits	Test method
Octane, RON	-	95.0 - 98.0	EN ISO 5164
Octane, MON	-	85.0 - 89.0	EN ISO 5163
Vapour pressure (DVPE)	kPa	56 - 60	EN 13016-1
Density at 15°C	kg/m ³	743.0 - 756.0	EN ISO 12185
Appearance at -7°C	-	Clear and Bright	-
Distillation at 70°C	% vol	34 - 46	EN ISO 3405
Distillation at 100°C	% vol	54 - 62	EN ISO 3405
Distillation at 150°C	% vol	86 - 94	EN ISO 3405
Final Boiling Point	°C	170 - 195	EN ISO 3405
Aromatics	% vol	25 - 32	EN 22854
Olefins	% vol	6 - 13	EN 22854
Benzene	% vol	< 1.00	EN 22854
Oxygen (ethanol only)	% mass	3.3 - 3.7	EN 22854
Sulfur	mg/kg	< 10	EN ISO 20846
Lead	mg/L	< 5	EN 237
Phosphorus	mg/L	1.3	ASTM D3231
Ethanol ^a	% vol	9 - 10	EN 22854
Water	% (v/v)	< 0.05	EN 12937
Oxidation stability	minutes	> 480	EN ISO 7536
Existent gum	mg/100 ml	< 4	EN ISO 6246
Copper corrosion	-	Class 1	EN ISO 2160

^aEthanol meeting EN 15376 is the only oxygenate to be intentionally added.

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EU regulation 2017/1151 - LPG

Parameter	Unit	Limit		Test method
		Fuel A	Fuel B	
Composition				ISO 7941
C ₃ content	% vol	28 – 32	83 – 87	
C ₄ content	% vol	Balance	Balance	
< C ₃ , > C ₄	% vol	< 2	< 2	
Olefins	% vol	< 12	< 15	
Evaporation residue	mg/kg	< 50	< 50	prEN 15470
Water at 0°C	-	Free	Free	prEN 15469
Total sulfur content	mg/kg	< 10	< 10	ASTM D6667
Hydrogen sulphide	-	None	None	ISO 8819
Copper strip corrosion ^a	Rating	Class 1	Class 1	ISO 6251
Odor	-	Characteristic	Characteristic	
Motor octane number	-	> 89	> 89	EN 589 Annex B

^a This method may not accurately determine the presence of corrosive materials if the sample contains corrosion inhibitors or other chemicals which diminish the corrosivity of the sample to the copper strip. Therefore, the addition of such compounds for the sole purpose of biasing the test method is prohibited.



EUROPEAN UNION

EU regulation 2017/1151 - Ethanol E75 for Testing at Low Ambient Temperatures

Parameter	Unit	Limits	Test method
Octane, RON	-	> 95.0	EN ISO 5164
Octane, MON	-	> 85.0	EN ISO 5163
Vapour Pressure	kPa	50 - 60	EN ISO 13016-1 (DVPE)
Density at 15°C	kg/m ³	Report	EN ISO 12185
Appearance ^a	-	Clear and Bright	Visual inspection
Sulfur	mg/kg	< 10	EN ISO 20846
Phosphorus ^b	mg/L	< 0.3	EN 15487
Ethanol and higher alcohols ^c	% vol	70 - 80	EN 1601
Higher alcohols (C ₃ -C ₈)	% vol	< 2	-
Methanol	% vol	< 0.5	-
Water	% (v/v)	< 0.3	ASTM E1064
Petrol ^d	% vol	Balance	EN228
Oxidation stability	minutes	> 360	EN ISO 7536
Existent gum	mg/100 ml	< 4	EN ISO 6246
Inorganic chloride	mg/L	< 1	ISO 6227
pHe	-	6.5 - 9	ASTM D6423
Copper strip corrosion	Rating	Class 1	EN ISO 2160
Acidity (CH ₃ COOH)	% m/m	< 0.005	ASTM D1613
	mg/L	< 40	
Carbon / hydrogen ratio	-	Report	-
Carbon / oxygen ratio	-	Report	-

^aTo be determined at ambient temperature or 15°C, whichever is higher. ^bThere shall be no intentional addition of compounds containing phosphorus, iron, manganese, or lead to this reference fuel. ^cEthanol to meet specification of EN 15376 is the only oxygenate that shall be intentionally added to this reference fuel. ^dThe unleaded petrol content can be determined as 100 minus the sum of the percentage content of water and alcohols.

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EUROPEAN UNION

EU regulation 2017/1151 - Ethanol: E85

Parameter	Unit	Limits	Test method
Octane, RON	-	> 95.0	EN ISO 5164
Octane, MON	-	> 85.0	EN ISO 5163
Vapour Pressure	kPa	40 - 60	EN ISO 13016-1 (DVPE)
Density at 15°C	kg/m ³	Report	EN ISO 12185
Appearance ^a	-	Clear and Bright	Visual inspection
Sulfur	mg/kg	< 10	EN ISO 20846
Phosphorus ^b	mg/L	< 0.3	EN 15487
Ethanol and higher alcohols ^c	% vol	83 - 85	EN 1601
Higher alcohols (C ₃ -C ₈)	% vol	< 2	-
Methanol	% vol	< 0.5	-
Water	% (v/v)	< 0.3	ASTM E1064
Petrol ^d	% vol	Balance	EN228
Oxidation stability	minutes	> 360	EN ISO 7536
Existent gum	mg/100 ml	< 5	EN ISO 6246
Inorganic chloride	mg/L	< 1	ISO 6227
pHe	-	6.5 - 9	ASTM D6423
Copper strip corrosion	Rating	Class 1	EN ISO 2160
Acidity (CH ₃ COOH)	% m/m	< 0.005	ASTM D1613
	mg/L	< 40	
Carbon / hydrogen ratio	-	Report	-
Carbon / oxygen ratio	-	Report	-

^aTo be determined at ambient temperature or 15°C, whichever is higher. ^bThere shall be no intentional addition of compounds containing phosphorus, iron, manganese, or lead to this reference fuel. ^cEthanol to meet specification of EN 15376 is the only oxygenate that shall be intentionally added to this reference fuel. ^dThe unleaded petrol content can be determined as 100 minus the sum of the percentage content of water and alcohols.

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EUROPEAN UNION

EU regulation 2017/1151 - Diesel B7

Parameter	Unit	Limits	Test method
Cetane Number	-	52 - 56	EN ISO 5165
Cetane Index	-	< 46	EN ISO 4264
Density at 15°C	kg/m ³	833.0 - 837.0	EN ISO 12185
Distillation at 50% point	°C	> 245.0	EN ISO 3405
Distillation at 95% point	°C	345.0 - 360.0	EN ISO 3405
Final Boiling Point	°C	< 370	EN ISO 3405
Flashpoint	°C	> 55	EN ISO 2719
Cloud point	°C	< -10	EN 23015
Viscosity at 40°C	mm ² /s	2.30 - 3.30	EN ISO 3104
Polycyclic aromatics	% mass	2.0 - 4.0	EN 12916
Sulfur	mg/kg	< 10	EN ISO 20846
Total contamination	mg/kg	< 24	EN 12662
Water content	mg/kg	< 200	EN ISO 12937
FAME ^a	% vol	6.0 - 7.0	EN 14078
Oxidation stability at 110°C ^b	hr	< 20	EN 15751
Copper corrosion	-	Class 1	EN ISO 2160
Conradson carbon residue	% m/m	< 0.2	EN ISO 10370
Ash content	% m/m	< 0.010	EN ISO 6245
Lubricity	wm	< 400	EN ISO 12156
Acid Number	mg KOH/g	< 0.10	EN ISO 6618

^aFAME content to meet the specification of EN 14214.

^bEven though oxidation stability is controlled it is likely that shelf life will be limited.

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EUROPEAN UNION

EU regulation 2017/1151 - Natural Gas/Biomethane

Parameter	Unit	Basis	Limits	Test method
Reference fuel G20				
Methane	% mole	100	99 – 100	ISO 6974
Balance ^a	% mole	-	< 1	ISO 6974
Sulfur Content ^b	mg/m ³	-	< 10	ISO 6326-5
Wobbe Index (net) ^c	MJ/m ³	48.2	47.2 – 49.2	-
Reference fuel G25				
Methane	% mole	86	84 – 88	ISO 6974
Balance ^a	% mole	-	< 1	ISO 6974
N ₂	% mole	14	12 – 16	ISO 6974
Sulfur Content ^b	mg/m ³	-	< 10	ISO 6326-5
Wobbe Index (net) ^c	MJ/m ³	39.4	38.2 – 40.6	-

^a Inerts (different from N₂) + C₂ + C₂₊.

^b Value to be determined at 293.2K and 101.3 kPa.

^c Value to be determined at 273.2 K and 101.3 kPa.

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EUROPEAN UNION

EU regulation 2017/1151 - Hydrogen for Internal Combustion Engines

Parameter	Unit	Limits	Test method
Hydrogen purity	% mole	98 – 100	ISO 14687-1
Total hydrocarbon	μmol/mol	0 – 100	ISO 14687-1
Water ^a	μmol/mol	^b	ISO 14687-1
Oxygen	μmol/mol	^b	ISO 14687-1
Argon	μmol/mol	^b	ISO 14687-1
Nitrogen	μmol/mol	^b	ISO 14687-1
CO	μmol/mol	0 – 1	ISO 14687-1
Sulfur	μmol/mol	0 – 2	ISO 14687-1
Permanent particulates ^c	-	-	ISO 14687-1

^aNot to be condensed.

^bCombined water, oxygen, nitrogen and argon: 1,900 μmol/mol.

^c The hydrogen shall not contain dust, sand, dirt, gums, oils or other substances in an amount sufficient to damage the fuelling station equipment or the vehicle (engine) being fueled.

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EUROPEAN UNION

EU regulation 2017/1151 - Hydrogen for Fuel Cell Vehicles

Parameter	Unit	Limits	Test method
Hydrogen ^a	% mole	99.99 – 100	ISO 14687-2
Total gasses ^b	μmol/mol	0 – 100	-
Total hydrocarbon	μmol/mol	0 – 2	ISO 14687-2
Water	μmol/mol	0 – 5	ISO 14687-2
Oxygen	μmol/mol	0 – 5	ISO 14687-2
Helium, Nitrogen, Argon	μmol/mol	0 – 100	ISO 14687-2
CO ₂	μmol/mol	0 – 2	ISO 14687-2
CO	μmol/mol	0 – 0.2	ISO 14687-2
Total sulfur compounds	μmol/mol	0 – 0.04	ISO 14687-2
Formaldehyde (HCHO)	μmol/mol	0 – 0.01	ISO 14687-2
Formic acid (HCOOH)	μmol/mol	0 – 0.2	ISO 14687-2
Ammonia (NH ₃)	μmol/mol	0 – 1	ISO 14687-2
Total halogenated compounds	μmol/mol	0 – 0.05	ISO 14687-2
Particle size	μm	0 – 10	ISO 14687-2
Particulates concentration	μg/L	0 – 1	ISO 14687-2

^a The hydrogen fuel index is determined by subtracting the total content of non-hydrogen gaseous constituents listed in the table (Total gases), expressed in mole percent, from 100 mole percent. It is less than the sum of the maximum allowable limits of all non-hydrogen constituents shown in the Table.

^b The value of total gases is summation of the values of the non-hydrogen constituents listed in the table, except the particulates.



US AND CALIFORNIA

US - certification unleaded gasoline fuel: E0

Fuel Name	E0	Gasoline	Gasoline	Cold CO	Cold CO
Specification		40 CFR 86.113-04	40 CFR 86.113-04	40 CFR 86.213-11	40 CFR 86.213-11
Property	Units	Ambient	High Altitude	Regular	Premium ^b
Octane ^a	RON	93 min.	93 min.		
Octane ^a	(R+M)/2			87.5 - 88.1 ^a	91.8 - 92.8 ^a
Sensitivity ^a	R-M	7.5 min.	7.5 min.	7.5 min.	7.5 min.
DVPE	PSI	8.7 - 9.2	7.6 - 8.0	11.2 - 11.8	11.2 - 11.8
IBP	°F	75 - 95	75 - 105	76 - 96	76 - 96
T10	°F	120 - 135	120 - 135	98 - 118	105 - 125
T50	°F	200 - 230	200 - 230	179 - 214	195 - 225
T90	°F	300 - 325	300 - 325	316 - 346	316 - 346
FBP	°F	415 max.	415 max.	413 max.	413 max.
Aromatics	% vol	35 max.	35 max.	22.4 - 30.4	28 - 36
Olefins	% vol	10 max.	10 max.	7.5 - 17.5	5.5 - 15.5
Saturates	% vol	Remainder	Remainder	Remainder	Remainder
Lead	g/L	0.013 max.	0.013 max.	-	-
	g/gal	-	-	0.01 max.	0.01 max.
Phosphorus	g/L	0.0013 max.	0.0013 max.	-	-
	g/gal	-	-	0.005 max.	0.005 max.
Sulfur content ^c	mg/kg	15 - 80	15 - 80	15 - 80	15 - 80

^a Octane specifications are optional for manufacturer testing. ^b The premium fuel specifications apply for vehicles designed to use high-octane premium fuel.

^c Sulfur content will not exceed 0.0045 weight percent for EPA testing.

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US AND CALIFORNIA

US - certification unleaded gasoline fuel: E10

Fuel Name	E10	EPA Tier 3	EPA Tier 3	EPA Tier 3	CARB LEV III
Specification		40 CFR 1065.71	40 CFR 1065.71	40 CFR 1065.71	40 CFR 86.113-07
Property	Units	General	Low-temp	High altitude	Regular
Octane	(R+M)/2	87.0 - 88.4 ^a	87.0 - 88.4 ^a	87.0 min.	87.0 - 88.4
Sensitivity	R-M	7.5 min.	7.5 min.	7.5 min.	7.5 min.
DVPE	PSI	8.7 - 9.2	11.2 - 11.8	7.6 - 8.0	6.9 - 7.2
T10	°F	120 - 140	110 - 130	120 - 140	130 - 150
T50	°F	190 - 210	190 - 210	190 - 210	205 - 215
T90	°F	315 - 335	315 - 335	315 - 335	310 - 320
FBP	°F	380 - 420	380 - 240	380 - 420	390 max.
Residue	ml	2.0 max.	2.0 max.	2.0 max.	2.0 Vol % max.
Aromatics	% vol	21.0 - 25.0	21.0 - 25.0	21.0 - 25.0	19.5 - 22.5
Olefins	% mass	4.0 - 10.0	4.0 - 10.0	4.0 - 10.0	4.0 - 6.0
Benzene	% vol				0.6 - 0.8
Lead	g/L	0.0026 max.	0.0026 max.	0.0026 max.	0.0026 max.
Phosphorus	g/L	0.0013 max.	0.0013 max.	0.0013 max.	0.0013 max.
Total Sulfur	mg/kg	8.0 - 11.0	8.0 - 11.0	8.0 - 11.0	8.0 - 11.0
Ethanol	% vol	9.6 - 10.0	9.6 - 10.0	9.6 - 10.0	9.2 - 10.0
Oxidation Stab.	minutes	1,000 min.	1,000 min.	1,000 min.	1,000 min.

^a Octane specifications apply only for testing related to exhaust emissions. For engines or vehicles that require the use of premium fuel, the adjusted specification for antiknock index is a minimum of 91.0 with no maximum.

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US AND CALIFORNIA

US - certification diesel fuel

Fuel property	Unit	Federal specifications 86.113-94	CARB specifications	Test ^b
		2-D		
Cetane Number (natural)	-	40 - 50	47 - 55	ASTM D613
Cetane Index	-	40 - 50	87.0 - 88.4	ASTM D976
Distillation Range	°F (°C)			D-86; 13 CCR section 2282(g) ^b
Initial Boiling Point	°F (°C)	340 - 400 (171.1 - 204.4)	340 - 420 (171 - 216)	
10% Point	°F (°C)	400 - 460 (204.4 - 237.8)	400 - 490 (204 - 254)	
50% Point	°F (°C)	470 - 540 (243.3 - 282.2)	470 - 560 (243 - 293)	
90% Point	°F (°C)	560 - 630 (293.3 - 332.2)	550 - 610 (288 - 321)	
End Point	°F (°C)	610 - 690 (321.1 - 365.6)	580 - 660 (304 - 349)	
API gravity		32 - 37	33 - 39	ASTM D4052
Total Sulfur	ppm	7 - 15	7 - 15	D-2622; 13 CCR section 2282(g) ^b
Nitrogen Content	ppm	-	100 - 500	13 CCR section 2282(g) ^b
Total Aromatic Hydrocarbons	% vol	27 (min.) ^a	8 - 12	D-1319; 13 CCR section 2282(g) ^b
Polycyclic Aromatic Hydrocarbons	% vol	-	1.4 (max.)	
Flashpoint (min.)	°F (°C)	130 (54.4)	130 (54)	ASTM D93
Viscosity at 40°F (4°C)	mm ² /sec.	2.0 - 3.2	2.0 - 4.1	ASTM D445

^a Remainder shall be paraffins, naphthenes and olefins.

^b ASTM standards and/or California Title 13, CCR procedures.

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PR OF CHINA

GB 17930-2016 Gasoline for motor vehicles (E0) (VI B)

Item	Quality indicators			Test method
	89	92	95	
Antiknock index (RON + MON)/2, not less than	84	87	90	GB/T 503, GB/T 5487
Lead content / (g/L), not more than	0.005			GB/T 8020
Distillation range:				GB/T 6536
10% evaporation temperature / °C, not more than	70			
50% evaporation temperature / °C, not more than	110			
90% evaporation temperature / °C, not more than	190			
Final distillation point / °C, not more than	205			
Residue (volume fraction) / %, not more than	2			
Vapor Pressure 1 November to 30 April	45 – 85			GB 8017
Vapor Pressure 1 May to 31 October	40 – 65 ^a			
Sulfur content ^b / (mg/kg), not more than	10			SH/T 0689
Benzene content ^c (volume percentage) / % not more than	0.8			SH/T 0713
Aromatics content ^d (volume percentage) / % not more than	35			GB/T 30519
Olefin content ^d (volume percentage) / % not more than	15			GB/T 30519

^a Guangxi follows this requirement throughout the year, and the districts in Guangdong and Hainan wherein the ethanol gasoline for motor vehicles (E10) is used shall follow this requirement throughout the year.

^b It may also follow the requirements in GB/T 11140, SH/T 0253, or ASTM D7039 for determination, and the method in SH/T 0689 shall prevail in case of objection.

^c It may also follow the requirements of SH/T 0713, GB/T 28768, or GB/T 30519 for determination, and the method in SH/T 0693 shall prevail in case of objection.

^d It may also follow the requirements of GB/T 11132 and GB/T 28768 for determination, and the method in GB/T 30519 shall prevail in case of objection.

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PR OF CHINA

GB 18351-2017 Ethanol Gasoline for motor vehicles (E10)(VI B)

Item	Quality indicators			Test method
	89	92	95	
Antiknock index (RON + MON)/2, not less than	84	87	90	GB/T 503, GB/T 5487
Distillation range:				GB/T 6536
10% evaporation temperature / °C, not more than	70			
50% evaporation temperature / °C, not more than	110			
90% evaporation temperature / °C, not more than	190			
Final distillation point / °C, not more than	205			
Residue (volume fraction) / %, not more than	2			
Vapor Pressure 1 November to 30 April	45 - 85			GB 8017
Vapor Pressure 1 May to 31 October	40 - 65 ^a			
Sulfur content ^b / (mg/kg), not more than	10			SH/T 0689
Benzene content ^c (volume percentage) / % not more than	0.8			SH/T 0693
Aromatics content ^d (volume percentage) / % not more than	35			GB/T 30519
Olefin content ^d (volume percentage) / % not more than	15			GB/T 30519

^a Guangxi follows this requirement throughout the year, and the districts in Guangdong and Hainan wherein the ethanol gasoline for motor vehicles (E10) is used shall follow this requirement throughout the year.

^b It may also follow the requirements in GB/T 11140, SH/T 0253, or ASTM D7039 for determination, and the method in SH/T 0689 shall prevail in case of objection.

^c It may also follow the requirements of SH/T 0713, GB/T 28768, or GB/T 30519 for determination, and the method in SH/T 0693 shall prevail in case of objection.

^d It may also follow the requirements of GB/T 11132 and GB/T 28768 for determination, and the method in GB/T 30519 shall prevail in case of objection.

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PR OF CHINA

GB 18047-2017 Compressed natural gas as vehicle fuel

Item	Technical indicator	Test method
Higher Heating Value (MJ/m ³)	≥ 31.4	GB/T 11062
Total Sulfur (as sulfur) (mg/m ³)	≤ 100	GB/T 11060.4
Hydrogen Sulfide (mg/m ³)	≤ 15	GB/T 11060.1
Carbon Dioxide mol:mol/%	≤ 3.0	GB/T 13610
Oxygen mol:mol/%	≤ 0.5	
Water (mg/m ³)	In specific geographical areas where vehicles operate, under conditions of pressure not exceeding 25 MPa and ambient temperature not lower than -13°C, the mass concentration of water should not exceed 30 mg/m ³	GB/T 17283 GB/T 22634
Dew Point / °C	In specific geographical areas where vehicles operate, under conditions of pressure not exceeding 25 MPa and ambient temperature below -13°C, the dew point should be at least 5°C lower than the lowest ambient temperature.	GB/T 17283 GB/T 22634

The standard reference conditions for gas volume in this standard are 101.325 kPa and 20°C.



PR OF CHINA

M100 methanol fuel for motor vehicles

Serial number	Test item	Test method	GB/T 42416-2023
1	Appearance	GB/T 511-2010	Clear and transparent, no suspended matter or precipitation
2	Methanol content (mass fraction)	GB/T 23510	≥ 99.5%
3	Density (20°C)	GB/T 4472	0.791 – 0.793 g/cm ³
4	Boiling range (0°C, 101.3 kPa, within 64.0–65.5°C, including 64.6°C ± 0.1°C)	GB/T 7534	≤ 1.2°C
5	Evaporation residue (mass fraction)	GB/T 6324.2	≤ 0.05%
6	Water content (mass fraction)	GB/T 6283	≤ 0.2%
7	Base number (as KOH)	SH/T 0251	0.003 – 0.030 mg/g
8	Nitrogen content	SH/T 0657	–
9	Organic chlorine content	GB/T 6324.9	≤ 1.0 mg/kg
10	Inorganic chlorine content (as Cl ⁻)	GB/T 23510	≤ 1.0 mg/L
11	Sulfur content	GB/T 34100	≤ 1.0 mg/kg
12	Sodium content	GB/T 17476	≤ 2.0 mg/kg
13	Iron content	SH/T 0712	≤ 0.01 g/L
14	Cleanliness (particle distribution)	GB/T 20082	≤ – 16/13 grade
15	Simulated intake valve deposit mass	GB/T 37322	–
16	Lubrication properties wear spot diameter / μm	SH/T 0765-2005 test temperature: 25°C	–

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Table 1 requirement for E20 reference fuel for use in positive ignition engines TA and COP tests

Characteristics	Requirements
Density at 15°C, kg/m ³	743 to 760
Distillation	
a) Percent evaporated at 70°C (E70°C), percent v/v	34 to 46
b) Percent evaporated at 100°C (E100°C), percent v/v	64 to 72
c) Percent evaporated at 150°C (E150°C), percent v/v, Min.	88 to 95
d) Final Boiling Point, °C, Max.	165 to 195
e) Residue, percent by volume, Max.	2
Research Octane Number (RON), Min.	98
Motor Octane Number (MON), Min.	88
Gumcontent (solvent washed), g/m ³ , Max.	40
Total Sulfur, mg/kg, Max.	10

Characteristics	Requirements
Lead Content (as Pb), g/L, Max.	0.005
Reid vapour pressure at 37.8°C, kPa, Max.	60 to 65
Benzene content, percent by volume, Max.	1
Copper strip corrosion (3 h at 50°C)	Class 1
Water tolerance of gasoline-alcohol blends, temperature for phase separation, °C, Max.	(-) 15
Induction period, minutes, Min.	480
Olefin content, percent by volume	6 to 13
Aromatic content, percent by volume	20 to 30
Oxygen content, percent by mass	7 to 7.4
Ethanol content, percent v/v	19 to 20
Water content, percent by volume, Max.	0.050
Phosphorus content, g/L, Max.	0.001



INDIA

Table 2 requirement for B6 to B20 Biodiesel Blend Fuel

Characteristics	Requirements
Density ^a at 15°C, kg/m ³	820 - 860
Kinematic viscosity at 40°C (cSt)	2.0 - 4.62
Flash point, Abel (°C) Min.	35
Sulfur ^b (mg/kg), Max.: a) BS III b) BS IV	350 50
Carbon residue (Ramsbottom) ^c on 10 percent residue, percent by mass), Max.	0.3
Ash content (percent by mass), Max.	0.01
Water, ppm, Max.	260
Cu corrosion, 3 h, Max.: a) BS III at 100°C b) BS IV at 50°C	1 1
Cetane No ^d , Min.	51

Characteristics	Requirements
Cetane index ^d , Min.	46
PAH, m/m Max.	11
Lubricity, wear scar diameter (wsd 1.4) at 60°C, micron, Max.	460
Acid No ^e , mg of KOH/gm Max.	0.2
Oxidation stability, at 110°C, h, Min.	20
Distillation, percent recovery at 360°C Min.	95
Biodiesel content, percent, v/v	6 - 20
Pour point ^f , Max.: a) Winter b) Summer	3°C 15°C
Cold filter plugging point (CFPP ^g), Max.: a) Winter b) Summer	6°C 18°C
Total contaminant, mg/kg, Max.	24

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JAPAN

Test gasoline fuel

Fuel properties	Unit	Regular	Premium	Test method
Lead		Not detected		JIS K2255
Sulfur Content	wt-ppm	10 or less		JIS K2541 - 1,2,6,7
Total Aromatics	% vol	20 - 45		JIS K2536 - 1,2,3
Olefins	% vol	15 - 25		JIS K2536 - 1,2
Benzene	% vol	1.0 or less		JIS K2536 - 2,3,4
Oxygen Content		Not detected		JIS K2536 - 2,4,6
MTBE		Not detected		JIS K2536 - 2,4,5,6
Methanol		Not detected		JIS K2536 - 2,4,5,6
Ethanol		Not detected		JIS K2536 - 2,4,6
Real Gum	mg/100 ml	5 or less		JIS K2261
Kerosene		Not detected		JIS K2536 - 2,4

Fuel properties	Unit	Regular	Premium	Test method
Octane Number				JIS K2280
RON		90 - 92	99 - 101	
MON		80 - 82	86 - 88	
Density	g/cm³	0.720 - 0.734	0.740 - 0.754	JIS K2249
Distillation Properties				JIS K2254
10% Distillation Temperature	K (°C)	318 - 328 (45 - 55)		
50% Distillation Temperature	K (°C)	363 - 373 (90 - 100)		
90% Distillation Temperature	K (°C)	413 - 443 (140 - 170)		
Final Boiling Point	K (°C)	488K (215) or less		
Vapor Pressure	kPa	56-60		JIS K2258

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JAPAN

Test diesel fuel

Fuel properties or substance name	Unit		Test method
Sulfur Content	wt-ppm	10 or less	JIS K2541 - 1,2,6,7
Cetane Index		53 - 57	JIS K2280
Density	g/cm ³	0.824 - 0.840	JIS K2249
Distillation Properties			JIS K2254
50% Distillation Temperature	K (°C)	528 - 568 (255 - 295)	
90% Distillation Temperature	K (°C)	573 - 618 (300 - 345)	
Final Boiling Point	K (°C)	643 (370) or less	
Total Aromatics	% vol	25 or less	JPI HPLC
Polycyclic Aromatic	% vol	5.0	JPI HPLC
Flash Point	K (°C)	331 (58) or higher	JIS K2265 - 3
Kinematic Viscosity (Test temperature 303K (30°C))	mm ² /s	3.0 to 4.5	JIS K2283

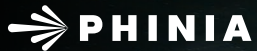


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EUROPEAN UNION - EURO 5 AND EURO 5+

Euro 5 limit values and test conditions

Requirements were set in Regulation (EU) 168/2013 amended by 134/2014, 2019/129 and 2020/1694.

Type I test limits, tailpipe emissions after cold start and applicable test cycle, valid from^a 1 January 2020 (NT) and 1 January 2021 (AT)

Vehicle category	Vehicle category name	Propulsion class	Mass of (mg/km)					Test cycle	Implementation dates	
			CO	THC	NHMC	NOx	PM		New types	All new vehicles
L1e-A	Powered cycle	PI / CI / Hybrid	500	100	68	60	4.5 ^b	Revised WMTC	1 Jan 2020	1 Jan 2021
L1e-B-L7e	All other L-category vehicles	PI / PI Hybrid	1,000	100	68	60	4.5 ^b	Revised WMTC	1 Jan 2020	1 Jan 2021
		CI / CI Hybrid	500	100	68	90	4.5	Revised WMTC		

^a Four-year delay for subtypes L6e-B, L2e-U, L3e-AxT and L3e-AxE (Euro 5+, see below).

^b Applicable to petrol direct injection (DI) engines only.

Euro 5+ Regulation (EU) 2019/139 amending Regulation (EU) No. 168/2013

Amendments to the OBD II requirements for certain vehicle types.

Four-year delay to implementation dates for certain vehicle types as shown in the above table.



EUROPEAN UNION - EURO 5

Euro 5 test type IV, evaporative emissions for vehicles with PI engines

Veh. cat. ^c	Vehicle category name	Permeation test ^{d,f} (mg/m ² /day)		Mass of THC in SHED test (mg/test)
		Fuel tank	Fuel tubing	Vehicle
L1e-A	Powered cycle	1,500	15,000	1,500
L1e-B	Two-wheel moped			
L2e	Three-wheel moped			
L3e L4 ^e	Two-wheel motorcycle with and without side-car	-	-	
L5e-A	Tricycle	-	-	
L5e-B	Commercial tricycle	1,500	15,000	
L6e-A	Light on-road quad	-	-	
L6e-B	Light quadrimobile	1,500	15,000	
L7e-A	Heavy on-road quad	-	-	
L7e-B	All-terrain quad	1,500	15,000	
L7e-C	Heavy quadrimobile			

^c For (sub)-categories L1e-A, L1e-B, L2e, L5e-B, L6e-B, L7e-B and L7e-C, applicable test type to be determined pending the results of a study references in Annex IV of Regulation EU 168/2013. Each subcategory will either be made subject to permeation testing or SHED testing.

^d Permeation test procedure set out in appendix 2 to Annex V of Reg. (EU) No. 134.2014.

^e Only the base two-wheel motorcycle to which the side-car is fitted must meet the appropriate emission limits.

^f Empty field means no limit defined in Euro 5 regulation.

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EUROPEAN UNION - EURO 5

Euro 5^a test type V, pollution of emission control devices, minimum distance accumulation^b

Vehicle category	Vehicle category name	Durability mileage (km)
L1e-A	Powered cycle	5,500
L3e-Axt ^c	Two-wheel trial motorcycle	
L1e-B	Two-wheel moped	11,000
L2e	Three-wheel moped	
L3e-AxE ^c	Two-wheel Enduro motorcycle	
L6e-A	Light on-road quad	
L7e-B	Heavy all-terrain quad	
L3e L4e	Two-wheel motorcycle with and without side-car ($V_{max} < 130$ km/h)	20,000
L5e	Tricycle	
L6e-B	Light quadrimobile	
L7e-C	Heavy quadrimobile	
L3e L4e	Two-wheel motorcycle with and without sidecar ($V_{max} \geq 130$ km/h)	35,000
L7e-A	Heavy on-road quad	

^a Also applicable to Euro 4.

^b Article 23(3a) full mileage accumulation, (3b) partial distance accumulation and (3c) mathematical application of deterioration factors set out in Reg. (EU) No. 168/2013.

^c x = 1, 2 or 3 (different sub-categories).

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EUROPEAN UNION - EURO 2 AND 3

Euro 2 and 3 limit values and test conditions

Requirements are defined in framework Dir. 2002/24/EC and Dir. 97/24/EC (repealed on 31 December 2015). Applicable vehicle categories shown in tables.

Euro 2 and 3 type I test limits, tailpipe emissions after cold start

Vehicle category	Vehicle category name	Classification (cm³)	Euro level	Emissions (mg/km)				Test cycle	Applicable as of
				CO	HC	NOx	HC+NOx		
L1e	Two-wheel moped	< 50	3 ^a	1,000	–	–	1,200	ECE R47	2000
L3e	Two-wheel motorcycle	< 150	3	2,000	800	150	–	ECE R40, UDC ^b	2006
		≥ 150	3	2,000	300	150	–	ECE R40, UDC+EUDC ^c	2006
Positive ignition									
L2e	Three-wheel mopeds	< 50	3 ^a	7,000	1,500	400	–	L2+L6: ECE R47 L5+L7 UDC	2003
L5e	Tricycles	≥ 50	2						
L6e	Light quadricycles	< 50	2+3 ^a						
L7e	Heavy quadricycles	≥ 50	2						
Compression ignition									
L2e	Three-wheel mopeds	< 50	2	2,000	1,000	650	–	L2+L6: ECE R47 L5+L7 UDC+EUDC	2003
L5e	Tricycles	≥ 50	2						
L6e	Light quadricycles	< 50	2						
L7e	Heavy quadricycles	≥ 50	2						

^a Sampling start $t = 0$, weighting 30% cold / 70% warm. ^b Emissions measured for all six modes – sampling start at $t = 0$. ^c Emissions measured from all modes – sampling start at $t = 0$.

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EUROPEAN UNION - EURO 4

Euro 4 limit values and test conditions

Revised type-approval package Euro 4 and Euro 5 steps: Reg. (EU) No. 168/2013 and Reg. (EU) No. 134/2014. Applicable vehicle categories shown in tables. Euro 4 Type I test limits, tailpipe emissions after cold start, and applicable test type, valid from 1 January 2016 (NT) and 1 January 2017 (AT).

Vehicle category	Vehicle category name	Propulsion class	Mass (mg/km)				Test cycle	Implementation dates	
			CO	HC	NOx	PM		New types	All new vehicles
L1e-A	Powered cycle	PI/CI/Hybrid	560	100	70	-	ECE R47	1 Jan 2017	1 Jan 2018
L1e-B	Two-wheel moped	PI/CI/Hybrid	1,000	630	170	-	ECE R47	1 Jan 2017	1 Jan 2018
L2e	Three-wheel moped	PI/CI/Hybrid	1,900	730	170	-	ECE R47	1 Jan 2017	1 Jan 2018
L3e L4e ^a L5e-A L7e-A	Two-wheel motorcycles with and without side-car	PI/PI Hybrid $V_{max} < 130$ km/h	1,140	380	70	-	WMTC Stage 2	1 Jan 2016	1 Jan 2017
	Tricycle	PI/PI Hybrid $V_{max} \geq 130$ km/h	1,140	170	90	-	WMTC Stage 2		
	Heavy on-road quad	CI/CI/Hybrid	1,000	100	300	80 ^b	WMTC Stage 2		
L5e-B	Commercial tricycle	PI/PI/Hybrid	2,000	550	250	-	ECE R40	1 Jan 2016	1 Jan 2017
		CI/CI/Hybrid	1,000	100	550	80 ^b	ECE R40		
L6e-A L6e-B	Light on-road quad	PI/PI Hybrid	1,900	730	170	-	ECE R47	1 Jan 2017	1 Jan 2018
	Light quadrimobile	CI/CI Hybrid	1,000	100	550	80	ECE R47		
L7e-B L7e-C	Heavy all terrain quad	PI/PI Hybrid	2,000	550	250	-	ECE R40	1 Jan 2016	1 Jan 2017
	Heavy quadrimobile	CI/CI Hybrid	1,000	100	550	80	ECE R40		

^a Only the base two-wheel motorcycle to which the side-car is fitted must meet the appropriate emission limits. ^b CI only, also if for example, a hybrid concept includes a CI engine.

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EUROPEAN UNION - EURO 4

Euro 4 test type IV, evaporative emissions for vehicles with PI engines

Veh. cat. ^a	Vehicle category name	Mass of THC (mg/test)	Test cycle
L3e L4e	Two-wheel motorcycle with and without side car	2,000	SHED ^b
L5e-A	Tricycle		
L6e-A	Light on-road quad		
L7e-A	Heavy on-road quad		

^a Vehicle Cat. L1e, L2e, L5e-B, L6e-B, L7e-B and L7e-C equipped with a plastic fuel storage tank are subject to the permeability test and limits set out in appendix 1 to Annex V of Reg. (EU) No. 134.2014.

^b SHED test procedure set out in appendix 3 to Annex V of Reg. (EU) No. 134.2014. For rapid ageing of the carbon canister an additive deterioration factor applies: 300 mg/test.



EUROPEAN UNION - TESTING FRAMEWORK

Euro 4 and 5 framework

Revised type-approval package Euro 4 and Euro 5 steps: Reg. (EU) No. 168/2013 and Reg. (EU) No. 134/2014. Applicable vehicle categories shown in tables. The following table summarises the required tests.

Test Type	Description	Euro 4 step	Euro 5 step
I	Tailpipe emission after cold start	Annex VI(A1)	Annex VI(A2)
II	- PI or Hybrid equipped with PI: emissions at idling and increased idling speed	Recasted Directive 2009/40/EC	
	- CI or Hybrid with CI engine: free acceleration test		
III	Emissions of crankcase gases	Zero emission, closed crankcase. Crankcase emissions shall not be discharged directly into the ambient atmosphere from any vehicle throughout its useful life	
IV	Evaporative emissions	Annex VI(C1)	Annex VI(C2)
V	Durability of pollution control devices	Annexes VI(A), VII(A), VII(B), Euro 4 limits and test procedures	Annexes VI(A), VII(A), VII(B), Euro 5 limits and test procedures
VI	A test-type VI has not been attributed	N/A	
VII	Energy efficiency: CO ₂ emissions, fuel and/or electric energy consumption and electric range	Measurement and reporting, no limit value for type-approval purposes	
VIII	OBD environment tests	OBD stage I, Annex VI(B1)	OBD stage II, Annex VI(B2)
IX	Sound level	Annex VI(D), Euro 4 limits and procedures	Annex VI(D), Euro 5 limits and procedures

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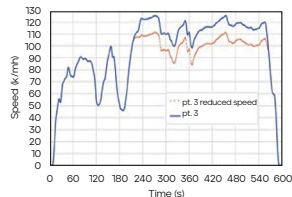
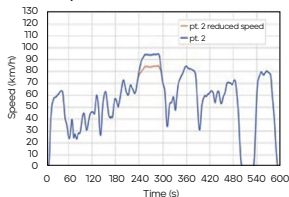
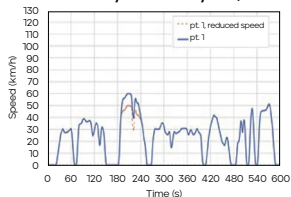
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EUROPEAN UNION - EMISSIONS TEST CYCLES

World Motorcycle Test Cycle (WMTC, UN GTR No. 2)



L-category vehicle class and subclass		Definition (Engine displacement D and maximum speed V_{max})	Applicable parts of the WMTC as specified in Appendix 6
Class 1		$D < 150 \text{ cm}^3$ and $V_{max} < 100 \text{ km/h}$	Part 1, reduced vehicle speed in cold condition, followed by part 1, reduced vehicle speed in warm condition
Class 2	Sub-class 2-1:	$D < 150 \text{ cm}^3$ and $100 \text{ km/h} \leq V_{max} < 115 \text{ km/h}$ or $D \geq 150 \text{ cm}^3$ and $V_{max} < 115 \text{ km/h}$	Part 1, reduced vehicle speed in cold condition, followed by part 2, reduced vehicle speed in warm condition
	Sub-class 2-2:	$115 \text{ km/h} \leq V_{max} < 130 \text{ km/h}$	Part 1, in cold condition, followed by part 2, in warm condition
Class 3	Sub-class 3-1:	$130 \leq V_{max} < 140 \text{ km/h}$	Part 1, in cold condition, followed by part 2, in warm condition, followed by part 3, reduced vehicle speed in warm condition
	Sub-class 3-2:	$D > 1,500 \text{ cm}^3$ or $V_{max} \geq 140 \text{ km/h}$	Part 1, in cold condition, followed by part 2, in warm condition, followed by part 3, in warm condition

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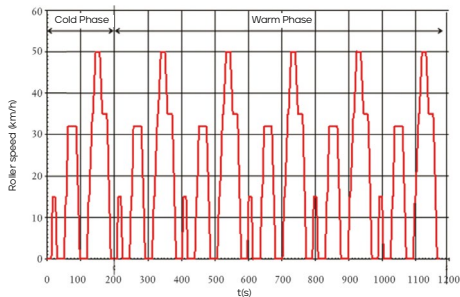
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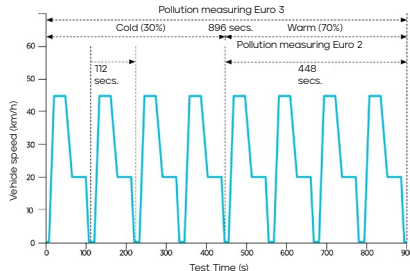


EUROPEAN UNION - EMISSIONS TEST CYCLES

UNECE R40-based cycle (Motorcycles - Reg. (EU) 134/2014)



UNECE R47-based cycle (mopeds - Dir. 2013/60/EU and Reg. (EU) 134/2014)



EU has not acceded R47, which is therefore not accepted for whole vehicle type-approval.

Set out in Dir. 2013/60/EU and 97/24/EC (until 31 December 2017) and set out in Reg. (EU) No. 134/2014 (voluntary after 11 September 2014, obligatory after 1 January 2018). NB the EU has not acceded to UN Reg. No 47 and which is therefore not accepted for whole vehicle type approval of mopeds.

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US FEDERAL AND CALIFORNIA - MOTORCYCLE STANDARDS

US Federal and California motorcycle limits

EPA adopted California standards in 40 CFR 86.410-2006

- Motorcycles tested to FTP 75 Schedule^a
- No crankcase emissions allowed
- Evaporative Emissions apply from MY 2008^b and permeation emissions must not exceed 1.5 g/m²/day for tanks and 15 g/m²/day for fuel lines

- Regulations are fuel neutral
- Banking and early introduction credits available
- Three-wheel vehicles included if they meet the On-Highway Motorcycle criteria. Mopeds and scooters are covered under Non-Road Recreational standards

CARB has started rulemaking activities for on-road motorcycles with the aim to introduce standards aligned to Euro 5.

Limit values (g/km)

Year ^c	Class	Disp. (cc)	Tier	HC corp. ave	CO	HC+NOx		Useful life (years / km)
						corp. ave	max	
2006+	I-A	0-49	Tier 1	1.0	12	1.4 ^d	5.0	5 / 6,000
	I-B	50-169	Tier 1	1.0	12	1.4 ^d	5.0	5 / 12,000
	II	170-279	Tier 1	1.0	12	1.4 ^d	5.0	5 / 18,000
2006-2009	III	≥ 280	Tier 1	-	12	1.4	5.0	5 / 30,000
2010+	III	≥ 280	Tier 2	-	12	0.8	2.5	5 / 30,000

^a Modified for motorcycles in Class I between 164 and 332 seconds.

^b 40 CFR 105.110 Evaporative emission standards or 40 CFR 1051.245 design based.

^c Two years earlier implementation for California.

^d Optional.

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PR OF CHINA - STAGE IV STANDARD

Limit values for the Stage IV standards

	Application date	Vehicle type	Vehicle class	Engine size V (cc)	Top vehicle speed $V_{\max}$ (km/h)	Emission limits (g/km)					Driving cycle	Durability (km)	OBD requirement	
						HC	NOx	CO	HC+NOx	PM				
China Stage IV	2018	2 Wheels	Mopeds	≤ 50	$V_{\max} \leq 50$	0.63	0.17	1	–	–	ECE R47	11,000	Stage I	
			I	$50 < V < 150$	$V_{\max} \leq 50$	0.38	0.07	1.14	–	–	WMTC I	20,000		
				$V < 150$	$50 < V_{\max} < 100$									
			II	$V < 150$	$100 \leq V_{\max} < 115$						WMTC II-1			
				$V \geq 150$	$V_{\max} < 115$						WMTC II-2			
				$V \leq 1,500$	$115 \leq V_{\max} < 130$									
			III	$V \leq 1,500$	$130 \leq V_{\max} < 140$	0.17	0.09	1.14	–	–	WMTC III-1	35,000		
				$V > 1,500$ or $V_{\max} \geq 140$							WMTC III-2			
		3 Wheels	Mopeds	≤ 50	$V_{\max} \leq 50$	0.73	0.17	1.9	–	–	ECE R47	11,000		
			PI engine	$V > 50$ or $V_{\max} > 50$			0.55	0.25	2	–	–	ECE R40		20,000
			CI engine	$V > 50$ or $V_{\max} > 50$			–	0.39	0.74	0.46	0.06			

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PR OF CHINA - OVERVIEW OF STANDARDS

Implementation dates of China L-category vehicle standards

	Stage	Standard	Implementation date	
			Type approval	All sales & registrations
China	Stage I	GB 14622-2002 (MCs) GB 18176-2002 (Mopeds)	Jan 2003	July 2003 (MCs) Jan 2004 (Mopeds)
	Stage II		Jan 2004 (MCs)	Jan 2005 (MCs)
			Jan 2005 (Mopeds)	Jan 2006 (Mopeds)
	Stage III	GB 14622-2007 (MCs) GB 18176-2007 (Mopeds)	July 2008	July 2009 ^a
	Stage IV	GB 14622-2016 (MCs) GB 18176-2016 (Mopeds)	July 2018	July 2019

^a This is the original implementation date; actual implementation date extended by 1 year.



PR OF CHINA - STAGE III STANDARD

Limit values for the Stage III standards

China Stage III (cont.)	Application date	Description	Engine size	HC (g/km)	NOx (g/km)	HC+NOx (g/km)	CO (g/km)	Driving cycle	Durability	Cold start
	2008	2W with Four-Stroke Engine	< 50 cc (Moped)	-	-	1.2	1	ECE R47	10,000 km	Yes
			50-150 cc	0.8	0.15	-	2	ECE R40	18,000 km 30,000 km	
			≥ 150 cc	0.3	0.15	-	2	ECE R40		
								+EUDC		
		3W with Two-Stroke Engine	< 50 cc (Moped)	-	-	1.2	3.5	ECE R47	10,000 km	
			≥ 50 cc	1	0.25	-	4	ECE R40	12,000 km 18,000 km 30,000 km	
		3W with Four-Stroke Engine	< 50 cc (Moped)	-	-	1.2	3.5	ECE R47	10,000 km	
			≥ 50 cc	1	0.25	-	4	ECE R40	12,000 km 18,000 km 30,000 km	

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INDIA BS VI LIMITS AND TEST CONDITIONS

Bharat Stage-VI (BS VI) standards for 2 wheeler vehicle models as per GSR 889(E) dated 16 September 2016

Limit Values for 2 wheelers fitted with PI & CI engines (from April 2020)

Vehicle		BS VI emission norms							
		CO mg/km	HC mg/km	NOx mg/km	NMHC mg/km	PM mg/km	Durability mileage (km) Type V	EVAP mg/test	OBD
PI Vehicles	1 & 2-1	1,000	100	60	68	4.5 ^a	20,000	1,500	Stage I & Stage II ^c
	2-2	1,000	100	60	68	4.5 ^a			
	3-1 & 3-2	1,000	100	60	68	4.5 ^a	35,000		
CI Vehicles	All	500	100	90	68	4.5 ^a	35,000	-	
	DF (for all classes)	1.3	1.3 (SI) 1.1 (CI)	1.3 (SI) 1.1 (CI)	1.3 (SI) 1.1 (CI)	1.0 (CI)	-	300 ^b	-

Mass Emission Standards (Bharat Stage VI) for 2 wheelers with Spark Ignition (PI) engines with cc ≤ 50 and V_{max} ≤ 50 km/hr

Pollutant	TA=COP norms mg/km	Deterioration factor (D.F.)	Test cycle (Cold start at T=0 sec.)
CO	500	1.2	IDC as per AIS 137
HC	350	1.2	
NOx	150	1.2	

^a Applicable to gasoline direct injection (DI) engines only.

^b Fixed DF of 300 mg/test shall be added to SHED test results. Alternative to fixed DF, manufacture may opt for ageing of evaporative emission control devices as per procedure specified in AIS 137 and as amended time to time.

^c OBD stage II will be applicable from 1 April 2023.

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INDIA BS VI LIMITS AND TEST CONDITIONS

Vehicle class descriptions and test cycles for BS VI

Standard	Description	Class	Definition	Test cycle
BS VI	2W vehicle classification and testing requirements	Class 1	$50 < D < 150 \text{ cc}, V_{\max} \leq 50 \text{ km/h}$ or $D < 150 \text{ cc}, 50 < V_{\max} < 100 \text{ km/h}$	Part 1 reduced speed cold (0.5) + Part 1 reduced speed hot (0.5)
		Class 2-1	$D < 150 \text{ cc}, 100 \leq V_{\max} < 115 \text{ km/h}$ or $D \geq 150 \text{ cc}, V_{\max} < 115 \text{ km/h}$	Part 1 reduced speed cold (0.5) + Part 1 reduced speed hot (0.5)
		Class 2-2	$115 \leq V_{\max} < 130 \text{ km/h}$	Part 1 cold (0.3) + Part 2 hot (0.7)
		Class 3-1	$130 < V_{\max} < 140 \text{ km/h}$	Part 1 cold (0.25) + Part 2 hot (0.5)
				+ Part 3 reduced speed (0.25)
Class 3-2	$V_{\max} \geq 140 \text{ km/h}$	Part 1 cold (0.25) + Part 2 hot (0.5) + Part 3 (0.25)		

D – engine displacement; $V_{\max}$ – maximum design speed. WMTC phase sequence. Values in square brackets are weighting factors



JAPAN

Table of historical limit values (g/km)

		Test mode	Unit	CO	HC	NMHC	NOx	PM ^a
2006/ 2007	Bicycle with engine ($\leq 50\text{cc}$)	2 wheel cold start mode	g/km	2.0	0.5	-	0.15	-
	Mini motorcycle ($\leq 125\text{cc}$)			2.0	0.3		0.15	
	Small motorcycle ($\leq 250\text{cc}$)			2.0	0.3		0.15	
	Medium motorcycle ($> 250\text{cc}$)			2.0 (2.7) ^b	0.40 (0.3)		0.20 (0.15)	
2012	Bicycle with engine ($\leq 50\text{cc}$)	WMTC mode	g/km	2.2	0.45	-	0.16	-
	Mini motorcycle ($\leq 125\text{cc}$)			2.62	0.27		0.21	
	Small motorcycle ($\leq 250\text{cc}$)			2.62	0.27		0.21	
	Medium motorcycle $> 250\text{cc}$			2.62 (3.48)	0.27 (0.36)		0.21 (0.28)	
2018	Class 1: 50cc to 150cc and $V_{\text{max}} < 50 \text{ km/h}$ or $< 150\text{cc}$ and V_{max} between 50 and 100 km/h	WMTC mode	g/km	1.14	0.3	-	0.07	-
	Class 2: $< 150\text{cc}$ and V_{max} between 100 and 130 km/h or $> 150\text{cc}$ and $V_{\text{max}} < 130 \text{ km/h}$			1.14 (1.58)	0.2 (0.24)		0.07 (0.10)	
	Class 3: $V_{\text{max}} > 130 \text{ km/h}$			1.14 (1.58)	0.17 (0.21)		0.09 (0.14)	
2020	Class 1: 50cc to 150cc and $V_{\text{max}} < 50 \text{ km/h}$ or $< 150\text{cc}$ and V_{max} between 50 and 100 km/h	WMTC mode	g/km	1.00 (1.33)	0.10 (0.13)	0.068 (0.088)	0.06 (0.096)	0.0045 (0.0063)
	Class 2: $< 150\text{cc}$ and V_{max} between 100 and 130 km/h or $> 150\text{cc}$ and $V_{\text{max}} < 130 \text{ km/h}$			1.00 (1.33)	0.10 (0.13)	0.068 (0.089)	0.06 (0.096)	0.0045 (0.0063)
	Class 3: $V_{\text{max}} > 130 \text{ km/h}$			1.00 (1.33)	0.10 (0.13)	0.068 (0.090)	0.06 (0.096)	0.0045 (0.0063)

^aPM limit is applied to gasoline direct injection engines only. ^b Values are for type approval. Values in () are for other purpose (prototype, parallel imported bike, etc.).



SOUTH KOREA

Table of historical limit values (g/km)

Standard	Application date	Description	Test cycle	CO (g/km)	HC (g/km)	NOx (g/km)	HC+NOx (g/km)	Evap (g/test)
Euro 2	Jan 2008	All 3W	CVS-40	7	1.5	0.4	–	–
Euro 3		2W < 150 cc PI	UDC Cold	2	0.8	0.15	–	
		2W > 150 cc PI	ECE40 + EUDC		0.3			
		2W < 45 km/h	CVS-47	1	–	–	1.2	
Euro 4	Jan 2017	2W ≤ 50 cc PI & V _{max} < 45 km/h	ECE R47	1	0.63	0.17	–	–
		2W ≤ 50 cc PI & V _{max} 45 km/h	WMTC	1.14	0.38	0.07		
		2W > 50 cc PI & V _{max} < 130 km/h				2.0, applied only for vehicles with V _{max} ≥ 130 km/h		
		2W > 50 cc PI & V _{max} 130 km/h			0.17			0.09
Euro 5	Jan 2020		WMTC	CO (g/km)	THC (g/km)	NMHC (g/km)	NOx (g/km)	Evap (g/test)
				1	0.1	0.68	0.6	1.5

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BRAZIL

Promot 5	Year	Models	Emissions (mg/km)						
			CO	THC	NMHC	NOx	PM	HCHO	CO ₂
Promot 5	Jan 2023	New models	1,000	100	68	60	4.5	20 or 30	Declare
	Jan 2025	All models	1,000	100	68	60	4.5	20	Declare
Promot 5	Year	Models	Idle CO ^a	Idle CO ^a 2000 RPM	Idle HC ^b	Annual Prod: < 10,000 units – CO, NMHC, NOx DF 1.3 and MP DF 1.0 DF as 493, Brazil Resolution OBD M ₁ – Jan 2023 – New models – EU n° 134/2014 and EU n°44/2014 OBD M ₂ – Jan 2025 – All models – EU n° 134/2014 and EU n°44/2014			
	Jan 2023	New models	5,000	3,000	50				
	Jan 2025	All models	5,000	3,000	50				

^a Dilution Factor < 2.5.

^b Limit in Hexane (C6).

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OTHER AREAS OF THE WORLD

	Standard	Description	Class	Definition	Test cycle
Chile	2012: LA-4 - Tier 2, ECE40+EUDC - Euro 3, WMTC - Euro 3				
Indonesia	Motorcycle emissions legislation is equivalent to Euro 3				
Singapore	Singapore Government's National Environment Agency is responsible for emissions legislation and air quality. Euro 4 emissions are currently in place for 2W and 3W vehicles				
Thailand	Level 7 standards, equivalent to Euro 4, are currently in force				
Vietnam	From 2017 motorcycle emissions standards equivalent to Euro 3 are applicable, nationally, replacing the Euro 2 level standards. They follow EU regulations				



OCTOBER 2025

WORLDWIDE EMISSIONS STANDARDS LIGHT-DUTY VEHICLES

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Worldwide Emissions Standards

An electronic version of this booklet is also available on our website.

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