Delphi Technologies

Worldwide emissions standards

Passenger cars and light duty vehicles

2020 | 21

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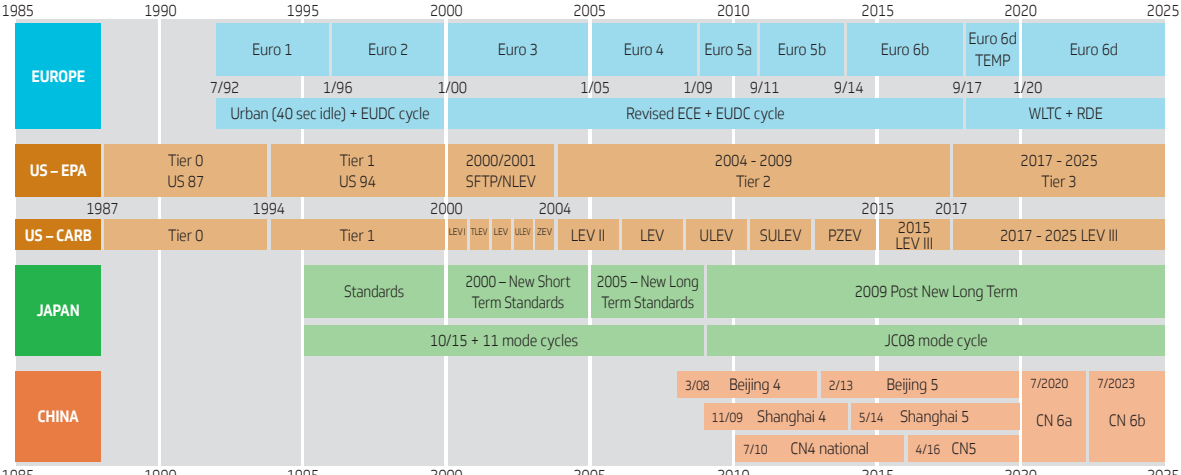

Dates show earliest type approval introduction only. More detail can be found in the booklet.

TIMELINE – TOXIC EMISSIONS STANDARDS PASSENGER CARS

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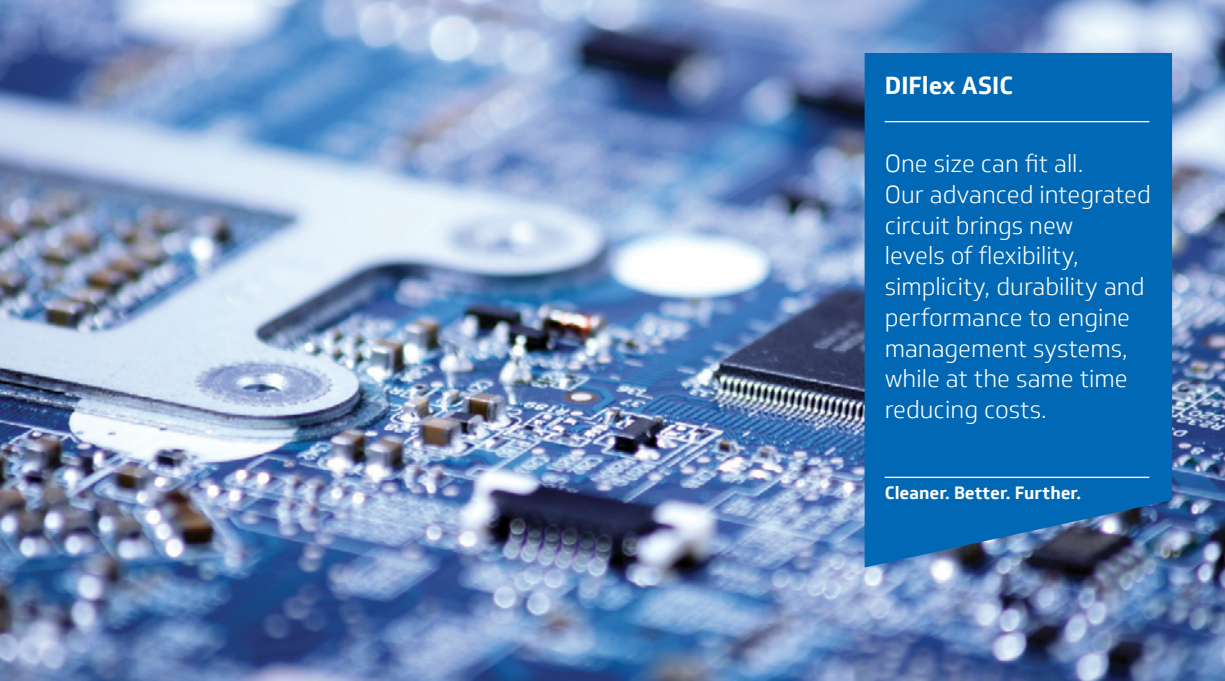


DIFlex ASIC

One size can fit all. Our advanced integrated circuit brings new levels of flexibility, simplicity, durability and performance to engine management systems, while at the same time reducing costs.

Cleaner. Better. Further.

EXHAUST EMISSIONS STANDARDS

ECE ECONOMIC COMMISSION FOR EUROPE

ECE regulations are similar to EU regulations. A base regulation is updated with a consecutive series of amendments. Dates of implementation differ from country to country, depending on the approval status of the respective amendment in that country. The series of ECE-R-83 regulations reflects the Euro 1-6 regulations. A worldwide harmonized test procedure/cycle (WLTP/WLTC) is currently being finalized (see pages 12-13).

EUROPEAN UNION

TYPE APPROVAL

Test	Description	Requirement
Type I	Tailpipe emissions[1)]	See EU standards in exhaust emissions section
Type II	CO emissions test at idling speed	Determination of reference value for inspection/maintenance and conformity of production (COP)
Type III	Crankcase gases emissions	Standard: zero emissions
Type IV	Evaporative emissions	See EU standards in Evap. section
Type V	Durability of anti-pollution devices	See EU standards in exhaust emissions section
Type VI	Low temperature test	
–	Onboard diagnostics	See EU standards in OBD section

VEHICLE CATEGORIES

Directive 70/156/EC, as amended by Directive 2007/46/EC

Category	Description	Sub-category	Number of persons	Mass limit	
M	Carriage of passengers, min 4 wheels, PC	M1	Up to 9		
		M2	>9	GVW ≤ 5.000 kg[2)]	
		M3		GVW > 5.000 kg	
N	Carriage of goods, min 4 wheels, LCV & HDV	N1 CL1	n.a.	GVW ≤ 3.500 kg	RM ≤ 1.305 kg
		N1 CL 2			1.305 kg < RM ≤ 1.760 kg
		N1 CL 3			1.760 kg < RM ≤ 3.500 kg
		N2		3.500 kg < GVW ≤ 12.000 kg	
		N3		GVW > 12.000 kg	

1) RDE Real World Driving Emissions to be included in this section starting September 2017.
2) Until Euro 4: Two subgroups: M1 w/ GVW ≤ 2.500 kg and M1 with 2.500 kg < GVW ≤ 3.500 kg.

EUROPEAN UNION

EURO 3-4 REQUIREMENTS

- On-board diagnostics requirements for gasoline, LPG, NG and diesel.
- Enhanced evaporative emissions requirements.
- Low temperature test for gasoline vehicles.
- Quality of market gasoline and diesel fuels (Dir 98/70/EC as amended by 2003/17/EC).
- Cold CO test.

Low temperature test

Vehicle Category	CO Limit (g/km)	THC Limit (g/km)
M1 and N1 CL1 < 2.5t GVW and/or ≤ 6 seats New types from 1/2002	15	1.8
N1 CL2, M1 > 6 seats, 2.5t < GVW ≤ 3.5t New types from 1/2003	24	2.7
N1 CL3 New types from 1/2003	30	3.2

- Measurement of HC and CO at -7°C (266K) during the urban part of the revised NEDC (780 seconds).
- Deterioration factors are not applied.
- Reference fuel option with higher Reid Vapor Pressure (RVP) and density.
- Gaseous fuel (LPG or NG) vehicles are exempt for the low temperature test.

EUROPEAN UNION

EURO 1-4 passenger cars Class M (≤ 2.500 kg GVW, ≤ 6 seats)

Directive		Euro 1 (EC 93)		Euro 2 (EC 96)		Euro 3 (EC 2000)		Euro 4 (EC 2005)	
		91/441/EEC or 93/59/EEC		94/12/EC or 96/69/EC		70/220/EC, as amended by 98/69/EC and 2003/76/EC			
Application date		TA 7/1992, FR 1/1993		TA 1/1996, FR 1/1997		TA 1/2000, FR 1/2001		TA 1/2005, FR 1/2006	
Test type		Urban (40 sec idle) + EUDC				Revised Urban + EUDC			
Combustion type		Positive ignition (PI)	Compression ignition (CI)	Positive ignition (PI)	Compression ignition (CI)[2]	Positive ignition (PI)	Compression ignition (CI)	Positive ignition (PI)	Compression ignition (CI)[4]
HC	g/km	–	–	–	–	0.2	–	0.1	–
NOx	g/km	–	–	–	–	0.15	0.5	0.08	0.25
HC+NOx	g/km	0.97 (1.13)[1]	0.97 (1.13)[1]	0.5	0.7	–	0.56	–	0.3
CO	g/km	2.72 (3.16)[1]	2.72 (3.16)[1]	2.2	1.0	2.3	0.64	1.0	0.5
PM	mg/km	–	140 (180)[1]	–	80	–	50	–	25
Deterioration factors		CO, HC+NOx: 1.4	CO: 1.1 HC+NOx: 1.0 PM: 1.2	CO, HC, NOx: 1.5	CO: 1.1 HC+NOx: 1.0 PM: 1.3	CO, HC, NOx: 1.2	CO: 1.1 HC+NOx, NOx: 1.0 PM: 1.2	CO, HC, NOx: 1.2	CO: 1.1 HC+NOx, NOx: 1.0 PM: 1.2
Durability	km	80,000	80,000	80,000	80,000	80,000 or 5 years	80,000 or 5 years	100,000 or 5 years[3]	100,000 or 5 years[3]
EOBD		–	–	–	–	EOBD	EOBD	EOBD	EOBD

1) COP values in brackets.
2) Limits for IDI Diesel. For DI Diesel up to 10/1999: HC+NOx: 0.9 g/km, CO 1g/km, PM 100 mg/km.
3) Required recording of in-use durability.
4) Up to 12/2002 Diesel cars with GVW > 2T and > 6 seats or off-road vehicles were considered as N1 vehicles.

EUROPEAN UNION

EURO 1-4 Large passenger cars and light commercial vehicles N1 (M > 2,500 kg GVW, 7-9 seats, LCV ≤ 3,500 kg GVW)

Directive		Euro 1 (EC 93)			Euro 2 (EC 96)						Euro 3 (EC 2000)						Euro 4 (EC 2005)					
		93/59/EEC			94/12/EC or 96/44/EC, 93/116/EC						70/220/EC, as amended by 98/69/EC and 2003/76/EC											
Vehicle class		CL 1[4]	CL 2[4]	CL 3[4]	CL 1[4]		CL 2[4]		CL 3[4]		CL 1		CL 2		CL 3[3]		CL 1		CL 2		CL 3[3]	
Application date		TA 10/1993, FR 10/1994			TA 1/97, FR 10/97		TA 1/98, FR 10/98		TA 1/98, FR 10/99		TA 1/2000, FR 1/2001		TA 1/2001, FR 1/2002				TA 1/2005, FR 1/2006		TA 1/2006, FR 1/2007			
Test type		Urban (40 sec idle) + EUDC									Revised Urban + EUDC											
Combustion type		Same limits for PI and CI			PI	CI	PI	CI	PI	CI	PI	CI	PI	CI	PI	CI	PI	CI	PI	CI	PI	CI
HC	g/km	–	–	–	–	–	–	–	–	–	0.2	–	0.25	–	0.29	–	0.1	–	0.13	–	0.16	–
NOx	g/km	–	–	–	–	–	–	–	–	–	0.15	0.5	0.18	0.65	0.21	0.78	0.08	0.25	0.1	0.33	0.11	0.39
HC+NOx[1]	g/km	0.97 (1.13)	1.4 (1.6)	1.7 (2.0)	0.5	0.7 (0.9)	0.6	1.0 (1.3)	0.7	1.2 (1.6)	–	0.56	–	0.72	–	0.86	–	0.3	–	0.39	–	0.46
CO[1]	g/km	2.72 (3.16)	5.17 (6.0)	6.9 (8.0)	2.2	1	4.0	1.25	5.0	1.5	2.3	0.64	4.17	0.8	5.22	0.95	1.0	0.5	1.81	0.63	2.27	0.74
PM[1][2]	mg/km	140 (180)	190 (220)	250 (290)	–	80 (100)	–	120 (140)	–	170 (200)	–	50	–	70	–	100	–	25	–	40	–	60

1) COP values in brackets.
2) Limits for Diesel.
3) Includes large passenger cars > 2,500 kg GVW.
4) Vehicle classes: Class 1 ≤ 1,250 kg, Class 2 > 1,250 kg and ≤ 1,700 kg, Class 3 > 1,700 kg. Reference weight in running order + 25 kg. EOBD for Euro 3+4 only. TA/FR dates differ for EOBD vs non-OBD related testing: See EOBD section for more details.

EUROPEAN UNION

EURO 5-6

Emissions	Unit	PC M[1], LCV N1 CL 1			LCV N1 CL 2			LCV N1 CL 3, N2		
		Euro 5a	Euro 5b/b+	Euro 6b, 6c, 6d-Temp, 6d	Euro 5a	Euro 5b/b+	Euro 6b, 6c, 6d-Temp, 6d	Euro 5a	Euro 5b/b+	Euro 6b, 6c, 6d-Temp, 6d
EURO 5-6 Positive ignition emissions limits ((EC) 715/2007 as amended (EC) 692/2008)										
THC	mg/km	100	100	100	130	130	130	160	160	160
NMHC		68	68	68	90	90	90	108	108	108
NOx		60	60	60	75	75	75	82	82	82
CO		1000	1000	1000	1810	1810	1810	2270	2270	2270
PM[2)3)]		5.0	4.5	4.5	5.0	4.5	4.5	5.0	4.5	4.5
PN[2)3)]	Nb/km	–	–	$6x10^{11}$ [4)]	–	–	$6x10^{11}$ [4)]	–	–	$6x10^{11}$ [4)]
EURO 5-6 Compression ignition emissions limits ((EC) 715/2007 as amended (EC) 692/2008)										
NOx	mg/km	180	180	80	235	235	105	280	280	125
HC+NOx		230	230	170	295	295	195	350	350	215
CO		500	500	500	630	630	630	740	740	740
PM[1)]		5.0	4.5	4.5	5.0	5.0	4.5	5.0	5.0	4.5
PN[1)]	Nb/km	–	$6x10^{11}$	$6x10^{11}$	–	$6x10^{11}$	$6x10^{11}$	–	$6x10^{11}$	$6x10^{11}$

1) For compression ignition only: exempted M1 vehicles have to comply w/ N1 CL3 test I limits. No more exemption for pass cars for Euro 6.
2) Test procedure defined in UN Reg 83 Suppl 7.
3) Applicable to PI DI engines only.
4) Until 3 years after the dates for TA/FR particle emission limit of 6*E12 may be applied for Euro 6b positive ignition DI vehicles upon request of manufacturer.

EUROPEAN UNION

EURO 5-6

- Vehicle scope
  M1 and M2, N1 and N2 vehicles as defined in Directive 70/156/EC with reference mass ≤ 2,610 kg.
  Extension possible at the manufacturer's request to M1, M2, N1, N2 with reference mass ≤ 2,840 kg.

- Exempted vehicles at Euro 5 stage
  Diesel M1 vehicles designed to fulfill specific social needs:
  – Special purpose vehicles with reference mass > 2,000 kg (ambulance, hearse, motor caravan, etc.)
  – Vehicles with reference mass > 2,000 kg and designed to carry at least 7 occupants.
  – Vehicles with reference mass > 1,760 kg and built specifically for commercial purposes to accommodate wheelchair use inside the vehicle.
  These vehicles still have to meet the N1 Class 3 limits for Euro 5.
- New reference fuels
  For Type 1 test: gasoline E5 E10 Flex fuel E85; Diesel B5 B7.
  For Type 6 test: gasoline E5 E10 Flex Fuel E75.

- Unrestricted and standardized access to vehicle repair and maintenance information.

There is no information for post Euro 6c/6d emissions levels available yet.

EUROPEAN UNION

EURO 5-6 IMPLEMENTATION ROADMAP
Regulation (EU) 2017/1151 amended by (EU) 2018/1832 applicable from 1 Jan 2019

Vehicle Class		Euro 5a	Euro 5b	Euro 6b	Euro 6c	Euro 6d-TEMP	Euro 6d-TEMP-ISC	Euro 6d-TEMP-EVAP-ISC	Euro 6d-ISC-FCM
M, N1 CL 1	TA	01 Sep 2009	01 Sep 2011	01 Sep 2014		01 Sep 2017	01 Jan 2019	01 Sep 2019	01 Jan 2020
	FR	01 Jan 2011	01 Jan 2013	01 Sep 2015	01 Sep 2018			01 Sep 2019	01 Jan 2021
N1 CL 2, 3 N2	TA	01 Sep 2010	01 Sep 2011	01 Sep 2015		01 Sep 2018		01 Sep 2019	01 Jan 2021
	FR	01 Jan 2012	01 Jan 2013	01 Sep 2016	01 Sep 2019			01 Sep 2020	01 Jan 2022

- Euro 6c = Euro 6b + 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.
- Euro 6d-TEMP = Euro 6b + final PN standard for PI vehicles + OBD Euro 6-2 + use of E10 and B7 reference fuel, assessed on regulatory lab test cycle + RDE testing against temporary Conformity Factors.
- Euro 6d-TEMP-ISC = Euro 6d-TEMP + new ISC procedure (incl. RDE, type 4, type 6 tests).
- Euro 6d-TEMP-EVAP-ISC = Euro 6d-TEMP-ISC + 48h evaporative test procedure.
- Euro 6d-ISC-FCM = Euro 6b + final PN standard for PI vehicles + OBD Euro 6-2 + use of E10 and B7 reference fuel, assessed on regulatory lab test cycle + RDE testing against final Conformity Factors + new ISC procedure + 48h evaporative emissions + onboard fuel and/or electric energy consumption monitoring device.

Lab test cycle is NEDC, it is replaced by WLTC with the introduction of Euro 6d-TEMP for new type, and Euro 6c for all vehicles one year later.

The Real Driving Emission (RDE) test procedure is 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).

EUROPEAN UNION

EURO 5-6

Durability Requirements starting Euro 5 (Type 5 test)

Deterioration factors are used to comply with emissions limits. They can be determined by one of the following three methods:

- Whole vehicle ageing test of 160,000 km.
- Bench ageing (or rapid ageing) durability test.
- Application of assigned deterioration factors.

Engines	Assigned deterioration factors						
	CO	THC	NMHC	NOx	HC+NOx	PM	PN
PI	1.5	1.3	1.3	1.6	–	1.0	1.0
CI[1)]	1.5	–	–	1.1	1.1	1.0	1.0

New In-Service Conformity

Min 6 months and 15,000 km, max 100,000 km or 5 years whichever is sooner. ISC is to be applied to Type 1 WLTP and RDE, Type 4 and Type 6 tests. ISC is opened to Type Approval Authorities and Third Parties testing.

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

This test shall not be done on CI vehicles. They only need to demonstrate at TA:

- Performance of NOx aftertreatment device reaching sufficiently high temperature for efficient operation within 400s after a cold start (-7°C).
- Operation strategy of the EGR system, including its functioning at low temperature.

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

Emission limit of PI vehicles for the carbon monoxide and total hydrocarbon tailpipe emissions after a cold start test:

Vehicle Category	CO Limit (g/km)	THC Limit (g/km)
M, N1, CL 1	15	1.8
N1, CL 2	24	2.7
N1 CL 3, N2	30	3.2

- The test consists of four elementary urban driving cycles (part one of the Type I test), placing the vehicle on a chassis dynamometer.
- The low ambient temperature test lasting a total of 780s shall be carried out without interruption and start at engine cranking.
- Before the test is carried out, the test vehicles shall be conditioned in a uniform manner to ensure that the test results may be reproducible.
- At the request of the manufacturer, the number of tests can be increased to 10 if the arithmetical mean of the first three results is lower than 110% of the limit. In this case, the requirement after testing is only that the arithmetical mean of all 10 results shall be less than the limit value.

1) DF for Euro 5 only. There is no Euro 6 DF for CI engines, manufacturers shall use the whole vehicle or bench ageing durability tests.

EUROPEAN UNION

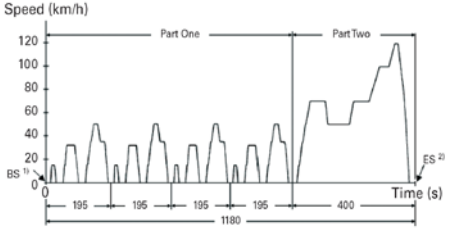
DRIVING CYCLES: NEDC

URBAN (ECE) + EXTRA-URBAN (EUDC) CYCLE.
Prior to Euro 3 (MVEG-A: ECE+EUDC).

- Bag sampling starts after 40s idle period.

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

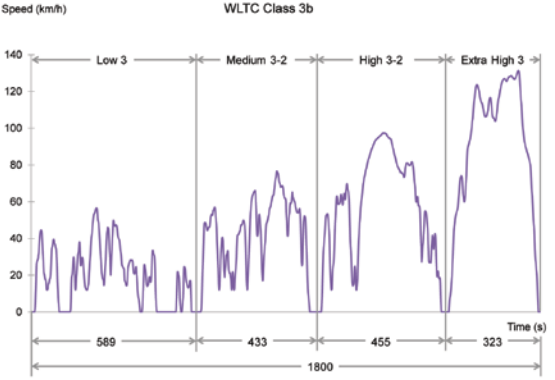
- Modification of the start-up phase: deletion of the 40s idle period prior to bag sampling.



1) BS: Beginning of Sampling at engine start.
2) ES: End of Sampling.

DRIVING CYCLES: WLTC

WLTC replace NEDC starting from Sept 2017 for new types and from Sept 2018 for all vehicles.



ECE – WLTC

The WLTC cycles are part of the Worldwide harmonized Light vehicles Test Procedures (WLTP in ECE global technical regulation Nr. 15).

- Scope: World harmonized way to determine Passenger Car emissions.
- Introduction in Europe Sep 2017 for TA and Sep 2018 for FR.
- Test Conditions: more representative of real World driving conditions. AC on/off, audio system on/off, battery state of charge, ambient temperature during test, vehicle test mass.
- Additional items within the framework of WLTP:
  - Additional pollutant regulations (Ethanol, Aldehydes, NO_2, N_2O, NH_3).
  - Definition of worldwide standardized method for particulate measurements.
  - Definition of lab procedure for hybrid and electrical vehicles for energy consumption.

Category		PMR (W/kg)	Speed Phases
Class 3	3a (v_{max} < 120 km/h)	PMR > 34	Low_3+$Medium_{3-1}$ +$High_{3-1}$+Extra $High_3$ [1]
	3b (v_{max} ≥ 120 km/h)		Low_3+$Medium_{3-2}$ +$High_{3-2}$+Extra $High_3$ [1]
Class 2		22 < PMR ≤ 34	Low_2+$Medium_2$ +$High_2$+Extra $High_2$ [2]
Class 1		PMR ≤ 22	Low_1+$Medium_1$+Low_1

Phase	Duration(s)	Phase	Duration(s)
Low Speed	589	High Speed	455
Medium Speed	433	Extra-High Speed	323
Tot. = 1800 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

1) At the option of the Contracting Party, the Extra High3 phase may be excluded.
2) At the option of the Contracting Party, the Extra High2 phase may be excluded.

EUROPEAN UNION – REAL DRIVING EMISSIONS

RDE is a new and additional vehicle test at type approval and throughout its normal life which can be conducted with market fuels. Certain types of pollutants are checked on public road in real life conditions using PEMS. The trip must include 3 portions: urban; rural and motorway in that order. Some payload may be added up to 90% of the allowed mass of passengers plus pay-mass of the vehicle.
The fourth package of the RDE test procedure is described in Annex IIIA of regulation (EU) 2017/1151 amended by (EU) 2018/1832 and applicable since 1 Jan 2019.

NOT TO EXCEED EMISSIONS VALUES FOR RDE TESTING

The emissions produced during the RDE trip are recorded every second and computed by a specific evaluation methods (see next pages). The RDE results must be corrected with the Ki factors or offsets developed in WLTP when periodically regenerating systems are present. The results of the RDE emissions for the entire RDE trip and the urban part alone have to remain below the Not to Exceed emissions limits as defined by the following equation:

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

Conformity Factors for Euro 6d RDE			
$CF_{pollutant}$	NOx	PN	CO[1)]
Temporary (Euro 6d-Temp)	2.1	1 + margin PN with margin PN = 0.5	–
Final (Euro 6d)	1 + margin NOx with margin NOx = 0.43	1 + margin PN with margin PN = 0.5	–

- "Margin" is a parameter taking into account additional measurement uncertainties of PEMS equipment, subject to annual review. On 13 December 2018, the General Court of the European Union delivered judgment in the Direct Actions T-339/16, T-352/16 and T-391/16, and annulled in part the RDE regulation on the margin NOx and the temporary CF for NOx of 2.1. The European Commission has appealed the judgment.

1) CO emissions shall be measured and recorded at RDE tests.

BOUNDARY CONDITIONS OF A VALID RDE TRIP

Ambient condition	Moderate	Extended
Emissions corrective factor	1	1/1.6
Temperature	0 ≤ T ≤ 30°C	-7 ≤ T < 0°C; 30 < T ≤ 35°C
Derogation till Jan 2020[1)]	3 ≤ T ≤ 30°C	-2 ≤ T < 3°C; 30 < T ≤ 35°C
Altitude	≤ 700m	700 < Alt ≤ 1300m

The ambient conditions become extended when the temperature or altitude conditions are extended. If during a particular time interval the ambient conditions are extended, the corrective factor shall be applied to the emissions during this particular time interval before being evaluated.

COLD ENGINE START

Cold start period is fully included in the urban part of the RDE trip and the whole trip.

- Duration of the cold start period is defined from engine start to first of 5min or Coolant Temp ≥ 70°C.
- Max speed during cold start ≤ 60 km/h.
- The average speed (including stops) shall be between 15 and 40 km/h.
- Total stop time during cold start < 90 s.
- Idling after ignition < 15 s.
- Vehicle conditioning for cold-start testing: driven for at least 30min followed by soak duration between 6 and 56 hours.
- If the last 3 hours of conditioning were done in extended averaged temperature conditions, then the corrective factor of 1/1.6 is always applied to emissions during cold start period. The corrective factor applies to pollutant emissions but not to CO_2.

1) Jan 2020 for type approval, Jan 2021 for first registration.

EUROPEAN UNION – REAL DRIVING EMISSIONS

TRIP VALIDATION

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

- Ambient boundary conditions shall be respected (see previous page).
- Trip requirements in term of distance shares, speeds, altitudes as defined in side table shall be met.
- Overall driving dynamics shall be within limits defined in table below, to check against:
  –> excessive driving dynamics using the v.a+ (velocity times 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[5]		
No Excess	**v ≤ 74.6 km/h**	**v > 74.6 km/h**
95th percentile (v.a+)	max (v.a+) = 0.136 . v + 14.44	max (v.a+) = 0.0742 . v + 18.966 max (v.a+)[6] = -0.097 . v + 31.635
Sufficiency	**v ≤ 94.05 km/h**	**v > 94.05 km/h**
Relative Positive Acceleration	min (RPA) = -0.0016 . v + 0.1755	min (RPA) = 0.025

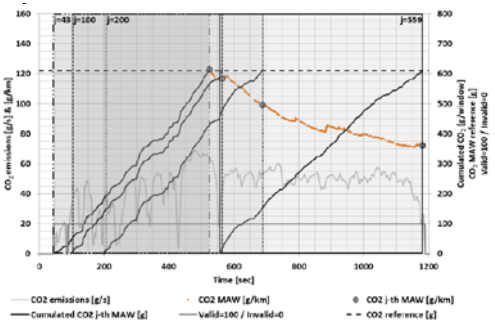
Trip requirements for a valid RDE test			
Driving portion	**Urban**	**Rural**	**Motorway**
	Speed ≤ 60 km/h	60 < Speed ≤ 90 km/h[1]	90 km/h[1] < Speed
Minimum distance	16 km	16 km	16 km
Distance share	29 - 44%	23 - 43%	23 - 43%
Total trip duration	90 - 120 minutes		
Average speed including stops	15 < Avg < 40 km/h[3]	–	–
Total stop time[4] (v < 1 km/h)	6 - 30% Urban time	–	–
Individual stop time	≤ 300 sec	–	–
v > 100 km/h [1] [2]	–	–	≥ 5 min
v > 145 km/h	–	–	< 3% Motorway time
Cumulative positive elevation gain	< 1200 m / 100 km		
Start/end test elevation difference	≤ 100 m		

1) 80 km/h for N2 vehicle with 90 km/h speed limiting device.
2) 90 km/h for M2 vehicle with speed limiting device at 100 km/h.
3) Applies also to cold start period.
4) Urban operation may contain several stop periods of 10s or longer.
5) v in the formulas are in km/h, v.a+ in m^2/s^3 or W/kg, RPA in m/s^2 or kWs/(kg.km).
6) upon the choice of the manufacturer for N1 and N2 vehicles with a power to mass ratio ≤ 44 W/kg.

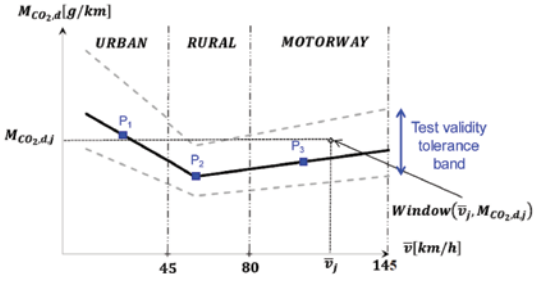
EUROPEAN UNION – REAL DRIVING EMISSIONS

MOVING AVERAGING WINDOWS

The MAW method defines windows every 1 sec which equal to 1/2 CO_2 mass generated during the entire WLTC. In each window, vehicle speeds and CO_2 emissions are averaged, and plotted as a point together with the vehicle CO_2 characteristic curve obtained from the WLTP test.



Vehicle CO_2 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)	$CO_{2\ LS\text{-}WLTP}$	$CO_{2\ HS\text{-}WLTP}$	$CO_{2\ EHS\text{-}WLTP}$



EUROPEAN UNION – REAL DRIVING EMISSIONS

VERIFICATION OF 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 CO_2 characteristic curve. The test is valid if it comprises at least 50% of the number of windows in each part.

	Urban	Rural	Motorway
Windows bins thresholds	Speed < 45 km/h	45 <= Speed < 80 km/h[1)]	80[1)] <= Speed < 145 km/h
Tolerances around CO_2 characteristic curve			
Upper tolerance	+ 45%[2)]	+ 40%[2)]	
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%

1) 70km/h for N2 vehicle with 90km/h speed limiting device.
2) For NOVC-HEV and OVC-HEV the upper tolerance may be increased by steps of 1% until 50%.

EUROPEAN UNION – REAL DRIVING EMISSIONS

RDE DATA EVALUATION

Both the urban and total trip emissions of the RDE have to pass the NTE emissions limits after correction with the Ki factors or offsets:

$M_{pollutant,RDE,u}$ [mg/km] and $M_{pollutant,RDE,t}$ [mg/km] < $NTE_{pollutant}$

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).

$$M_{pollutant,RDE,k}\left[\frac{mg}{km}\right] = \frac{Pollutant\ Mass\ Emitted_{RDE,k}}{Distance\ driven_{RDE,k}} \cdot RF_k$$

RF_k is defined based on the distance specific (g/km) CO_2 ratio r_k between the RDE and the WLTP (k = urban; k = total) according to side graph.

- For ICE and NOVC-HEV, r_k is computed as: with $M_{CO2,WLTP,k}$ defined in side table.

$$r_k = \frac{M_{CO_2,RDE,k}}{M_{CO_2,WLTP,k}}$$

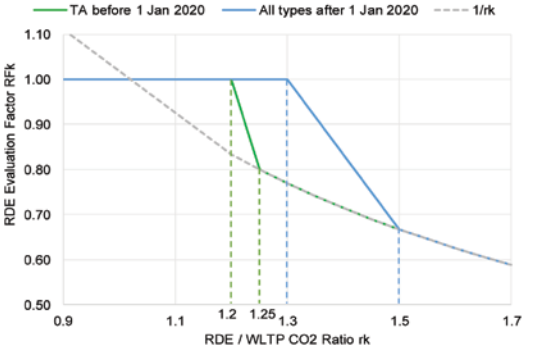
- For OVC-HEV, rk is computed as:

$$r_k = \frac{M_{CO_2,RDE,k}}{M_{CO_2,WLTP-CS,t}} \cdot \frac{0{,}85}{IC_k}$$

with IC_k being defined as:

$$IC_k = \frac{distance\ driven\ with\ the\ ICE\ on\ in\ total/urban}{total/urban\ distance}$$

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 $M_{CO2,WLTP,k}$		
k	**urban**	**total**
ICE	Low + medium speed	Whole WLTP cycle
NOVC-HEV	Whole WLTP cycle	
OVC-HEV	Whole WLTP cycle in charge sustaining mode	

US FEDERAL

TIER 2 STANDARDS

- 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, pick up trucks and vans).
- Emissions limits are fuel neutral, i.e. applicable to gasoline, diesel and all other fuels.
- Vehicles also have to meet Tier 2 limits on Supplemental Federal Test Procedure.
- 0.07g/mi NOx fleet average at 120,000 mi / 10 yrs phased in 25/50/75/100% from 2004-2007 for cars and trucks < 6,000 lbs GVWR, and 50/100% in 2008/2009 for heavier trucks.
- 8 standards "bins" are available as long as the manufacturer's fleet averages 0.07 g/mi NOx.
- 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+.

1) Bins 9-11 expired in 2006 for LD vehicles and LD trucks and in 2008 for HLD trucks and MD Passenger vehicles.
2) Pollutants with 2 numbers have a separate certification standard (1st number) and in-use standard (2nd number).

LIGHT DUTY VEHICLES – LIGHT DUTY TRUCKS – MEDIUM DUTY PASSENGER VEHICLES

Standard (g/mi)	Emissions Limits (50,000 mi)					Emissions Limits at Full Useful Life (120,000 mi)				
	NOx	NMOG	CO	PM	HCHO	NOx	NMOG	CO	PM	HCHO
Bin 1	–	–	–	–	–	0.00	0.00	0.0	0.00	0.000
Bin 2	–	–	–	–	–	0.02	0.01	2.1	0.01	0.004
Bin 3	–	–	–	–	–	0.03	0.055	2.1	0.01	0.011
Bin 4	–	–	–	–	–	0.04	0.07	2.1	0.01	0.011
Bin 5	0.05	0.075	3.4	–	0.015	0.07	0.09	4.2	0.01	0.018
Bin 6	0.08	0.075	3.4	–	0.015	0.10	0.09	4.2	0.01	0.018
Bin 7	0.11	0.075	3.4	–	0.015	0.15	0.09	4.2	0.02	0.018
Bin 8[2]	0.14	0.100/ 0.125	3.4	–	0.015	0.20	0.125/ 0.156	4.2	0.02	0.018
Bin 9[1][2]	0.20	0.075/ 0.140	3.4	–	0.015	0.30	0.090/ 0.180	4.2	0.06	0.018
Bin 10[1][2]	0.40	0.125/ 0.160	3.4/ 4.4	–	0.015/ 0.018	0.60	0.156/ 0.230	4.2/ 6.4	0.08	0.018/ 0.027
Bin 11[1]	0.60	0.195	3.4	–	0.022	0.90	0.28	7.3	0.12	0.032

US FEDERAL

TIER 3 STANDARDS

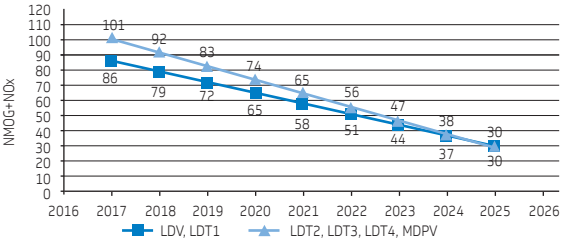
- Tier 3 emissions standards were adopted in Mar 2014 and phase-in 2017-2025. The regulation also tightens sulfur limits for gasoline.
- Both the certification limits (Bins) and the fleet average standards are expressed using the sum of NMOG+NOx emissions.
- The required emission durability has been increased to 150,000 mi or 15 yrs whichever comes first.
- Gasoline vehicles are tested – for exhaust and evaporative emissions – using gasoline containing 10% of ethanol (E10).

TIER 3 FTP STANDARDS

Tier 3 Certification Bin Standards (FTP, 150,000 mi)				
Bin	**NMOG+NOx (mg/mi)**	**PM1) (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 have been harmonized to create one set of limits for all 50 states.

TIER 3 FLEET AVERAGE NMOG+NOx FTP PHASE-IN (MG/MI)



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

1) In MY 2017-20 PM standard applies only to that segment of a manufacturer's vehicles covered by the percent of sales phase-in for that model year.

US FEDERAL

TIER 3 STANDARDS

COLD CO TEST

Fleet average requirement for NMHC:

- Provisions for carry forward and carry-back of credits.
- Provision for carry-over programs with respect to in-use testing.
- Test is on FTP cycle at 20°F.
- Flex fueled vehicles only required to provide assurance that same emission reduction systems are used on non-gasoline fuel as on gasoline.
- LDV < 6,000 GVWR: Fleet average NMHC = 0.3 g/mi CO = 10 g/mi. Phase-in 25/50/75/100 from MY 2010-2013.
- 6,000 ≤ LDV < 8,500 GVWR and MDPV < 10,000 lbs: Fleet average NMHC = 0.5 g/mi CO = 12.5 g/mi. Phase-in 25/50/75/100 from MY 2012-2015; 120 k mi durability limits.

50°F/10°C STANDARDS

- California only.

HWFET

Tier 2: 120 k mi durability; NOx Standard: 1.33 x applicable 120,000 vehicle bin.
Tier 3: 150 k mi durability; NMOG + NOx = 1.0 x applicable 150,000 vehicle bin.

TIER 3 PARTICULATE PHASE-IN

Phase-in of Tier 3 PM FTP Standards (mg/mi)						
Phase-in	**2017**	**2018**	**2019**	**2020**	**2021**	**2022+**
% of Sales	20[1)]	20	40	70	100	100
Certification Standard	3	3	3	3	3	3
In-use Standard	6	6	6	6	6	3

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

TIER 3 SFTP FLEET AVERAGE PHASE-IN

Tier 3 Fleet Average NMOG+NOx SFTP Standards									
Emission	**2017[2)]**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
NMOG+NOx (mg/mi)	103[1)]	97	90	83	77	70	63	57	50
CO (g/mi)	4.2								

- Manufacturer self select SFTP standards for each vehicle family.
- Self selected standards not to exceed 180 mg/mi.

1) Manufacturers comply in MY 2017 with 20% of their LDV and LDT fleet under 6,000 lbs GVWR, so alternatively with 10% of their total LDV, LDT, and MDPV fleet.
2) For LDVs and LDTs over 6,000 lbs GVWR and MDPVs, the fleet average standards apply beginning in MY 2018.

TIER 3 US06 PM PHASE-IN

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

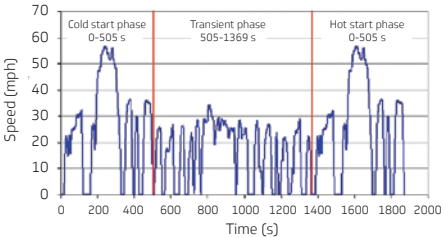
- Tier 3 US06 PM standards apply to each vehicle category separately.
- In-use standard is relaxed until phase-in is complete.

TIER 3 STANDARDS (OTHER)

- Useful Life: The Clean Air Act prohibits requiring useful life > 120 k mi. Tier 3 150k standards may be met at 120,000 km by multiplying the respective standard x 0.85 and routing to nearest mg/mi FTP limit. Other cycles standards remain the same for either useful life period.
- High Altitude: Tier 3 standards allow limited relief at high attitude. Manufacturers may comply with one bin higher at altitude. Bin 70 is capped at 105 mg/mi and Bin 160 gets no relief altitude.
- Enrichment Limits: Enrichment for otto-cycle engines throughout the US06 cycle is limited to lean best torque ÷ 1.04. See 40CFR 86.1811-17.
- Phase-in provisions: These include relaxed in-use standards, transitional Tier 3 Bins and Interim 4,000 SFTP standards.

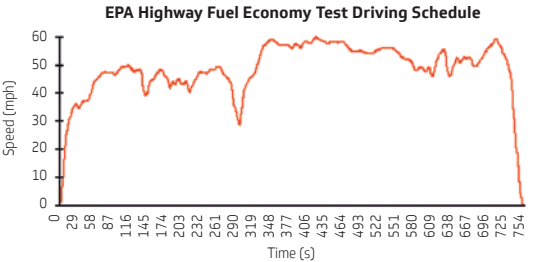
US FEDERAL AND CALIFORNIA

CITY DRIVING CYCLE[1)]



Total duration: 1,874 s (+hot soak: 540 s min, 660 s 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)

HIGHWAY DRIVING CYCLE[2)]



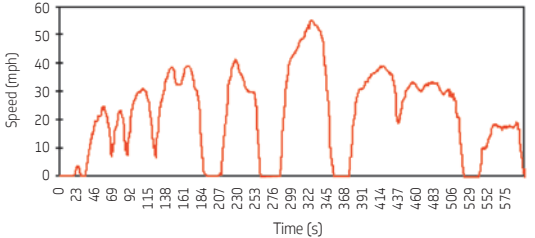
Total duration: 765 s
Length: 10.26 mi (16.5 km)
Average speed: 48.30 mph (77.7 km/h)
Max speed: 59.91 mph (96.4 km/h)

1) Also known as FTP 75, EPA III – Phase I + II, also known as: FTP 72, EPA II, UDDS, LA-4.
2) Also known as Highway Fuel Economy Test – HWFET.

US FEDERAL AND CALIFORNIA

SC03 AIR CONDITIONING DRIVING CYCLE

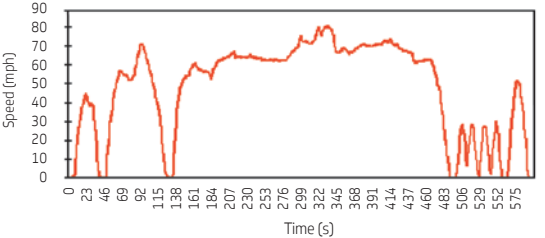
SC03 – Speed Correction Driving Schedule



Total duration:	598 s
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 s

US06 HIGH SPEED/HIGH LOAD DRIVING CYCLE

US06 or Supplemental FTP Driving Schedule



Total duration:	596 s
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 s
Max. acceleration:	8 mph/s

CALIFORNIA

LEV II STANDARDS

Passenger Cars or Light Duty Trucks ≤ 8,500 lbs

Durability (mi)	Emission Category	NMOG (g/mi)	CO (g/mi)	NOx (g/mi)	Formalde-hyde (g/mi)	Particulates (g/mi)
50,000	LEV	0.075	3.4	0.05	15	n/a
	LEV Option 1			0.07		
	ULEV	0.040	1.7	0.05	8	
120,000	LEV	0.090	4.2	0.07	18	0.01
	LEV Option 1			0.10		
	ULEV	0.055	2.1	0.07	11	
	SULEV	0.010	1.0	0.02	4	
150,000 (optional)	LEV	0.090	4.2	0.07	18	
	LEV Option 1			0.10		
	ULEV	0.055	2.1	0.07	11	
	SULEV	0.010	1.0	0.02	4	

LEV Option I applies to GVW > 3,151 lbs up to 4% of fleet.

LEV II 50°F/10°C FTP STANDARDS

Take LEV II emission standards from previous table:

- NMOG = 2 x LEV II standard.
- Same CO & NOx standard as LEV II.

LEV III STANDARDS

- LEV III standards phase-in 2015-25 MY. Beginning 2020 MY all vehicles need to be certified to LEV III.
- Both the certification limits (bins) and fleet average standards are expressed as NMOG+NOx emissions.
- The required emission durability has been increased to 150,000; up from 120,000 mi.

LEV III FTP STANDARDS

Passenger Cars and Light Duty Trucks ≤ 8,500 lbs

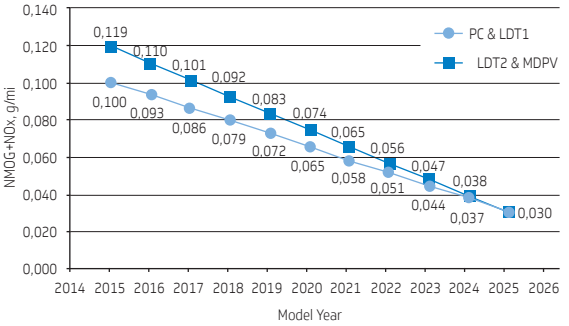
Durability (mi)	Emission Category [1]	NMOG+ NOx (g/mi)	CO (g/mi)	Formalde-hyde (g/mi)	Particulates [2] (g/mi)
150,000 (optional)	LEV160	0.160	4.2	4	0.01
	ULEV125	0.125	2.1	4	0.01
	ULEV70	0.070	1.7	4	0.01
	ULEV50	0.050	1.7	4	0.01
	SULEV30	0.030	1.0	4	0.01
	SULEV20	0.020	1.0	4	0.01

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

1) The numeric portion of the category name is the NMOG+NOx value in mg/mi.
2) These standards shall apply only to the vehicles not included in the phase-in of particulate standards.

CALIFORNIA

LEV III NMOG+NOx FLEET AVERAGE PHASE-IN



LEV III 50°F/10°C FTP STANDARDS

Light Duty Trucks and Medium Duty Passenger Vehicles for 2015-2019

Emission Category	NMOG+ NOx (g/mi)		HCHO (g/mi)
	Gasoline	Alcohol Fuel	Both Gasoline & Alcohol Fuel
LEV160	0.320	0.320	0.030
ULEV125	0.250	0.250	0.016
ULEV70	0.140	0.250	
ULEV50	0.100	0.140	
SULEV30	0.060	0.125	0.008
SULEV20	0.040	0.075	

LEV III PARTICULATE PHASE-IN

Year	PC, LDT, MDPV		Year	PC, LDT, MDPV	
	Percent of vehicles certified to :			Percent of vehicles certified to :	
	PM = 3 mg/mi	PM = 1 mg/mi		PM = 3 mg/mi	PM = 1 mg/mi
2017	10	0	2023	100	0
2018	20		2024	100	0
2019	40		2025	75	25
2020	70		2026	50	50
2021	100		2027	25	75
2022	100		2028	0	100

CALIFORNIA

SFTP NMOG+NOx AND CO COMPOSITE EXHAUST EMISSION STANDARDS

- A manufacturer must certify LEV II and LEV III LEVs, ULEVs, such that the manufacturer's sales-weighted fleet average NMOG+NOx composite emission value, does not exceed the applicable NMOG+NOx 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.
- In case of fuel-flexible vehicles, SFTP compliance shall be demonstrated using the LEV III certification gasoline.

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:

Composite Emission Value = 0.28 x US06 + 0.37 x SC03 + 0.35 x FTP [Eq. 1]

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 FTP test

LEV III SFTP INDIVIDUAL STANDARDS

SFTP NMOG+NOx and CO Stand-Alone Exhaust Emission Standards for MY 2012 onwards LEV III Passenger Cars, Light Duty Trucks and Medium Duty Passenger Vehicles

Vehicle Type	Durability (mi)	Emission Category [1]	US06 Test (g/mi)		SC03 Test (g/mi)	
			NMOG+NOx	CO	NMOG+NOx	CO
All PCs; LDTs 0-8,500 lbs GVWR; and MDPVs	150,000	LEV	0.140	9.6	0.100	3.2
		ULEV	0.120	9.6	0.070	3.2
		SULEV (Option A)[2]	0.060	9.6	0.020	3.2
		SULEV	0.050	9.6	0.020	3.2

1) Emission 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.

2) Optional SFTP SULEV Standards: Manufacturers may certify light duty truck test groups from 6,000 t or 8,500 lbs. GVWR and MDPV test groups to the SULEV, option A, emission standards 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 mi. Passenger cars and light duty trucks 0-6,000 lbs GVWR are not eligible for this option.

CALIFORNIA

LEV III SFTP FLEET AVERAGE PHASE-IN

SFTP NMOG+NOx and CO Composite Emission Standards for MY 2015 onwards Light Duty Trucks and Medium Duty Passenger Vehicles (g/mi) [1]											
	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+NOx Composite Exhaust Emission Standards [2]										
	0.140	0.110	0.103	0.097	0.090	0.083	0.077	0.070	0.063	0.057	0.050
	CO Composite Exhaust Emission Standard										
	4.2										

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 [3]					
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

1) 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.
2) Determining NMOG+NOx Composite Emission Values of LEV II Test Groups: For test groups certified to LEV II FTP emission standards, SFTP emission values shall be converted to NMOG+NOx and projected out to 120,000 mi or 150,000 mi (depending on LEV II FTP certification) using deterioration factors or aged components. NMHC emission values for the US06 and SC03 test cycles shall be converted to NMOG emission values by multiplying by a factor of 1.03. In lieu of deriving a deterioration factor specific to SFTP test cycles, carry-over test groups may use the applicable deterioration factor from the FTP cycle in order to determine the carry-over composite emission values for the purpose of the NMOG+NOx sales-weighted fleet-average calculation. If an SFTP full-useful life emission value is used to comply with SFTP 4 K standards, that value may be used in the sales-weighted fleet-average without applying an additional deterioration factor.
3) 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.

JAPAN

EMISSIONS STANDARDS – GASOLINE AND LPG VEHICLES

			Test Mode	Unit	CO	NMHC	NOx	PM[1]
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	0.005
		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	0.007
Future Regulations	2018	Passenger Car	WLTP	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)

1) PM limit applied for stoichiometric direct injection gasoline engines. It will be effective from Dec, 2020 for new vehicles and Nov, 2022 for existing vehicles. Number in bracket is upper limited value.

JAPAN

EMISSIONS STANDARDS – DIESEL VEHICLES

			Test Mode	Unit	CO	NMHC[1)]	NOx	PM
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
Future Regulations	2018	Passenger Car	WLTP				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

1) HC used for New Short Term.

JAPAN

OTHER REQUIREMENTS

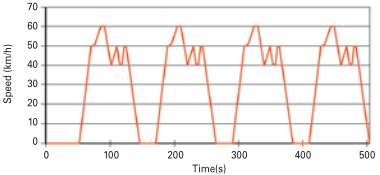
Test Mode		Exhaust emissions are calculated as follows: From Oct 2005: 10-15 mode hot start x 0.88 + 11 mode cold start x 0.12. From Oct 2008: 10-15 mode hot start x 0.75 + JC08 mode cold start x 0.25. Since Oct 2011: JC08 mode hot start x 0.75 + JC08 mode cold start x 0.25. From 2019: WTLP. Japan has a plan to introduce RDE regulation for some diesel vehicles. (GVW < 2.5 t, or less than 9 people) from Oct 2022 for new Type Approvals, and from Oct 2024 for Continuous Production Vehicles. RDE test procedure will differ from RDE in Europe due to different driving conditions. RDE method will be based on 3 phases WLTC.
In-use Vehicle Emission Limit		PC: Idle CO: 1%, Idle HC: 300 ppm. Small car (K-car) : Idle CO: 2%, Idle HC: 500 ppm. Diesel Smoke: non-load acceleration limit 25% / max PM: 0.8 m^{-1}.
Durability		PC, truck and bus GVW < 3.5 t: 80,000 km.
Evaporative Emissions – Gasoline and LPG		Test similar to EC 2000 Evap test: Test limit: 2.0 g/test. 1 h hot soak at 27 ± 4°C HSL test + 48 h diurnal (20-35°C) DBL test. Preparation driving cycle for EVAP: JC08 mode.
OBD – Gasoline and LPG		J-OBDII obligation: Enhanced OBD: detect any malfunctions causing excessive emissions on the test cycle.
Fuel Quality	**Gasoline**	Lead: Not detected (JIS K2255-4,5) MTBE: max. 7 vol.% Sulfur: max. 0.001 mass% Oxygen: max. 1.3 vol.% (JIS K2536-2,4,6) Benzene: max. 1 vol.%
	Diesel	Sulfur: max. 0.001 mass% Distillation at 90%: max. 360°C (JIS K2254) Cetane index: min. 45 (JIS K2280)

JAPAN

DRIVING CYCLES

11 MODE COLD CYCLE

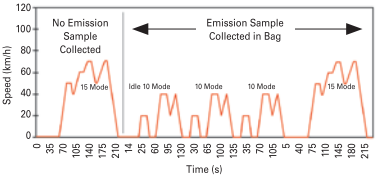
Japan 11 mode



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

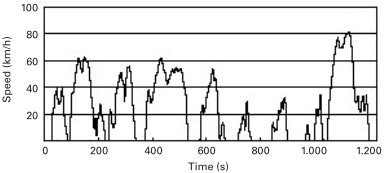
10-15 MODE COLD CYCLE

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
Average speed: 22.7 km/h

Driving cycle JC 08



Distance: 8.2 km
Max. speed: 80 km/h
Duration: 1205 s
Average speed: 24.4 km/h

BRAZIL

"PROCONVE" STANDARDS FOR GASOLINE PC, LCV AND DIESEL LCV

Vehicle	Standard (g/km)	NMHC	CO	NOx[1]	HCHO[4]	PM[2]
PC	L5	0.05	2.0	0.12 (0.25)	0.02	0.05
	L6		1.3	0.08	0.02	0.025
LCV ≤ 1,700 kg	L5	0.05	2.0	0.12 (0.25)	0.02	0.05
	L6		1.3	0.08	0.02	0.03
LCV > 1,700 kg	L5	0.06	2.7	0.25 (0.43)	0.04	0.06
	L6		2.0	0.25 (0.35)	0.03	0.04

- 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.

"PROCONVE" STANDARDS PHASE-IN

- PROCONVE L5: CY 2009 onwards.
- PROCONVE L6: CY 2014 onwards.
- PROCONVE L7: CY 2022 onwards.
- PROCONVE L8: CY 2025 onwards.
- From CY 2002: Fixed deterioration factors for annual production < 15,000 vehicles: CO and HC 1.2. NOx 1.1.
- FTP-75 cycle, durability 80,000 km/5 years.
- Evaporative emissions: PROCONVE L5 onwards: 1.5 g/test.
- Fuels: Certification required with E22 fuel for E22 vehicles.
  Certification required with E22/E60/E100 and CNG for a tri-fuel vehicle.
- Highway cycle test (E22 and E100 fuels – ABNT NBR 7024).

1) Diesel limits in brackets.
2) Particulate matter for diesel only.
3) Proposal stage only.
4) aldehyde limits for Otto cycle vehicles only.

BRAZIL

"PROCONVE L7" STANDARDS FOR GASOLINE PC, LCV AND DIESEL LCV

Vehicle	NMOG+NOx (mg/km)	PM[1] (mg/km)	CO (mg/km)	Aldeidos[3] (mg/km)	NH3[2] (ppm)	Evap[5] (g/test)	ORVR[5] (mg/L)
PC	80	6	1000	15	to be declared	0.5	50
LCV ≤ 1,700 kg	140[3]	6[3]					
LCV > 1,700 kg	320[4]	20[4]		–		–	–

- From CY 2002: Unburned ethanol is not allowed to be deducted from hydrocarbon emission results.
- FTP-75 cycle, durability 160,000km/10 years.
- Evaporative emissions: PROCONVE L7 onwards: 0.5 g/test day per 48 hours continuous 2023 20% of total sales, 2024 60% of total sales, 2025 10% of total sales.
- Fuels for PROCONVE L7 and L8:
  Certification required with E22 fuel for E22 vehicles,
  Certification required with E22/E60/E100 and CNG for a tri-fuel vehicle.
- FTP 75 cycle test Proconve L7 and L8 (E22 and E100 fuels –
  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 – ABNT NBR 7024).

1) Applicable to ignition spark engines, GDI and engines with Diesel cycle.
2) Applicable to engines with Diesel cycle with post treatment with liquid reducing agent.
3) Applicable to ignition spark engines only.
4) Applicable to engines with Diesel cycle only.
5) Not applicable to engines with Diesel and GNV cycle.

BRAZIL

"PROCONVE L8" STANDARDS FOR GASOLINE PC, LCV AND DIESEL LCV

			Level	NMOG+NOx (mg/km)	PM[1] (mg/km)	CO (mg/km)	Aldeidos[3] (mg/km)	NH3[2] (ppm)	Evap[5] (g/test)	ORVR[5] (mg/L)
Diesel Light-Duty Vehicles			320	320	20	1000	–	10	0.5	50
			280	280	20	1000	–			
			250	250	20	1000	–			
			220	220	10	1000	–			
			200	200	10	1000	–			
			170	170	9	1000	–			
	Light-Duty Vehicles ignition spark engines, > 1700 Kg of ME (4)		140	140	6	1000	15			
			110	110	6	1000	15			
		Passenger Light Vehicles and Light Duty Vehicles	80	80	6	1000	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	null	null

1) Applicable to ignition spark engines, GDI and engines with Diesel cycle.
2) Applicable to engines with Diesel cycle with post treatment with liquid reducing agent.
3) Otto Cycle vehicle only.
4) ME—Test mass.

PR OF CHINA

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[5)]	EU Reference
Type 1	–	GVW ≤ 2,500 kg	M1 vehicles for no more than 6 passengers including driver
Type 2	I	RM ≤ 1,305 kg	Other light-duty vehicles (including N1 light commercial vehicles)
	II	1,305 kg < RM ≤ 1,760 kg	
	III	RM > 1,760 kg	

In May 2018 it was reported that the city of Shenzhen will implement the China 6b standards starting 1 July 2018 for light-duty diesel vehicles and from 1 January 2019 for light-duty gasoline vehicles. There are also reports that the city of Guangzhou is planning early implementation of China 6b, starting 1 January 2019.

IMPLEMENTATION DATES

Stage / Standard		Reference	Region	Implementation dates	
				TA	FR
CN4 GB 18352.3-2005		Euro 4	Nationwide	01 Jul 2010	PI: 01 Jul 2011 CI: 01 Jan 2015
			Beijing (B4)	01 Mar 2008	
			Shanghai	01 Nov 2009	
CN5 GB 18352.5-2013		Euro 5	Nationwide	01 Apr 2016 [1)2)] 01 Jan 2017 [1)] 01 Jan 2018 [3)]	
			Beijing (B5)	PI w/o IUPR, CI: 01 Feb 2013 PI w/ IUPR: 01 Jan 2015	
			Shanghai	01 May 2014 [1)4)]	
CN6a	GB 18352.6-2016	Euro 6	Nationwide	01 Jul 2020	
CN6b			Nationwide	01 Jul 2023	

1) Light duty gasoline vehicles and public buses, sanitary and postal vehicles.
2) In 11 Eastern provinces only (Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan).
3) All vehicles.
4) Gasoline vehicles.
5) RM reference mass is replaced by TM test mass starting CN6.

PR OF CHINA

CN4-5 EMISSION STANDARDS – POSITIVE IGNITION ENGINES

Stage	Category	Class	CO	THC	NMHC	NOx	PM	PN
			g/km					Nb/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[1)]	–
	Type 2	I	1.00	0.10	0.068	0.060	0.0045[1)]	–
		II	1.81	0.13	0.090	0.075	0.0045[1)]	–
		III	2.27	0.16	0.108	0.082	0.0045[1)]	–

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

CN 4-5 EMISSION STANDARDS – COMPRESSION IGNITION ENGINES

Stage	Category	Class	CO	THC + NOx	NOx	PM	PN
			g/km				Nb/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	$6x10^{11}$

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	1.1	1.0

1) Applies only to direct injection positive ignition engines.

PR OF CHINA

CHINA 6 – EMISSION STANDARDS

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 N_2O limit is applied.

Stage	Category	Class	CO	THC	NMHC	NOx	N_2O	PM	PN[1]
			mg/km						Nb/km
CN6a	Type 1		700	100	68	60	20	4.5	6×10^{11}
	Type 2	I	700	100	68	60	20	4.5	6×10^{11}
		II	880	130	90	75	25	4.5	6×10^{11}
		III	1000	160	108	82	30	4.5	6×10^{11}
CN6b	Type 1		500	50	35	35	20	3.0	6×10^{11}
	Type 2	I	500	50	35	35	20	3.0	6×10^{11}
		II	630	65	45	45	25	3.0	6×10^{11}
		III	740	80	55	50	30	3.0	6×10^{11}

1) PN limit of $6x10^{12}$ applies to gasoline vehicles until July 2020.

CHINA 6 - REAL DRIVING EMISSIONS

CN6b includes a RDE test based on Euro 6 RDE pack2 with conformity factors of CF=2.1 both for NOx and PN.
RDE emissions test conformity will be applicable to all vehicles from July 2023.
Until July 2023, RDE tests results are monitored and reported.
Until July 2022, CF are subject to evaluation and verification.
The cold start period is recorded but excluded from RDE data evaluation.
A further extended condition is added for altitude comprised between 1300 m and 2400 m with an emission corrective factor of 1/1.8.
Only MAW data evaluation method is to be used.

PR OF CHINA

CHINA 6 – DURABILITY REQUIREMENTS

Deterioration factors or values are used to comply with emissions limits during Type 1 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.
- Engine bench ageing durability test.
- Application of the assigned deterioration factors or values from the following tables.

Engines	Assigned deterioration factors (CN6)						
	CO	THC	NMHC	NOx	N_2O	PM	PN
PI	1.8	1.5	1.5	1.8	1.0	1.0	1.0
CI	1.5	1	1	1.5	1.0	1.0	1.0

Engines	CN	Corrected deterioration values (CN6)						
		CO	THC	NMHC	NOx	N_2O	PM	PN
PI	6a	150	30	20	25	0	0	0
	6b	110	16	10	15	0	0	0
CI	6a	150	0	0	25	0	0	0
	6b	110	0	0	15	0	0	0

CHINA 5 & 6 – 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.

CN6 includes a low temperature emissions test at -7°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.

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

INDIA

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

VEHICLE CATEGORIES

The vehicle classification is consistent with the EU one. The regulation applies to categories M1, N1 Class I, N1 Class II, N1 Class III, and N2 with a reference mass not exceeding 2,610kg.
If required by manufacturers, the LD regulation 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.

EMISSION TESTING

The test cycle is a modified version of the NEDC, with maximum speed limited to 90 km/h (120 km/h in NEDC).
BS VI gasoline vehicles are certified with E10 and diesel vehicles with B7.
For BS VI – OBD – I and BS VI – OBD – II, real world driving emission measurement using PEMS is provided by the Automotive Industry Standard (AIS-137). During type approval and COP applicable from 1st April 2020, real world driving cycle emission measurement using PEMS shall be carried out for data collection and from 1st April 2023, real world driving cycle emission conformity shall be applied.

IMPLEMENTATION DATES

Standard	Date	Region
BS IV (ref. Euro 4)	01 Apr 2010	NCR[1], 13 cities[2][3]
	01 Jul 2015	Above plus 29 cities[4]
	01 Oct 2015	North India + bordering districts of Rajasthan (9 States)
	01 Apr 2016	Western India + parts of South and East India (10 States and Territories)
	01 Apr 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.	
BS VI (ref. Euro 6)	01 Apr 2020	Nationwide

1) National Capital Region (Delhi).
2) Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Secunderabad, Ahmedabad, Pune, Surat, Kanpur and Agra.
3) Above cities plus Solapur and Lucknow. The program was later expanded with the aim of including 50 additional cities by March 2015.
4) Mainly in the states of Haryana, Uttar Pradesh, Rajasthan and Maharastra.

INDIA – BHARAT STAGE IV

EMISSION STANDARDS – POSITIVE IGNITION ENGINES

Stage	Vehicle			CO	THC	NOx
	Category	Class	Reference Mass (RM) (kg)	mg/km		
BS IV	M (GVW ≤ 2500 kg or less than 6 seaters)	–	All	1000	100	80
	N1 & M (GVW > 2500 kg or more than 6 seaters)	I	RM ≤ 1305	1000	100	80
		II	1305 < RM ≤ 1760	1810	130	100
		III	RM > 1760	2270	160	110

EMISSION STANDARDS – COMPRESSION IGNITION ENGINES

Stage	Vehicle			CO	THC + NOx	NOx	PM
	Category	Class	Reference Mass (RM) (kg)	mg/km			
BS IV	M (GVW ≤ 2500 kg or less than 6 seaters)	–	All	500	300	250	25
	N1 & M (GVW > 2500 kg or more than 6 seaters)	I	RM ≤ 1305	500	300	250	25
		II	1305 < RM ≤ 1760	630	390	330	40
		III	RM > 1760	740	460	390	60

Engine Category	BS IV: Assigned Deterioration Factor				
	CO	THC	NOx	HC + NOx	PM
PI	1.2	1.2	1.2	–	–
CI	1.1	–	1	1	1.2

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.

INDIA – BHARAT STAGE VI

EMISSION STANDARDS – POSITIVE IGNITION ENGINES

Stage	Vehicle			CO	THC	NMHC	NOx	PM[1]	PN[1][2]
	Category	Class	Ref. Mass (RM) (kg)	mg/km					Nb/km
BS VI	M (M1 & M2)	–	All	1000	100	68	60	4.5	6×10^{11}
	N1	I	RM ≤ 1305	1000	100	68	60	4.5	6×10^{11}
		II	1305 < RM ≤ 1760	1810	130	90	75	4.5	6×10^{11}
		III	RM > 1760	2270	160	108	82	4.5	6×10^{11}
	N2	–	All	2270	160	108	82	4.5	6×10^{11}

1) Applies only to direct injection positive ignition engines.
2) Until three years after date of implementation for new type approvals and new vehicles, PN limit of 6×10^{12} Nb/km shall apply to BS VI PI DI vehicles upon choice of the manufacturer.

EMISSION STANDARDS – COMPRESSION IGNITION ENGINES

Stage	Vehicle			CO	THC + NOx	NOx	PM	PN
	Category	Class	Reference Mass (RM) (kg)	mg/km				Nb/km
BS VI	M (M1 & M2)	–	All	500	170	80	4.5	6×10^{11}
	N1	I	RM ≤ 1305	500	170	80	4.5	6×10^{11}
		II	1305 < RM ≤ 1760	630	195	105	4.5	6×10^{11}
		III	RM > 1760	740	215	125	4.5	6×10^{11}
	N2	–	All	740	215	125	4.5	6×10^{11}

Engine Category	BS VI: Assigned Deterioration Factor						
	CO	THC	NMHC	NOx	HC+ NOx	PM	PN
PI	1.5	1.3	1.3	1.6	–	1.0	1.0
CI	1.5	–	–	1.1	1.1	1.0	1.0

- 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.

SOUTH KOREA

VEHICLE CATEGORIES

From 1/2009:

- Mini-car < 1000 cc.
- Small PC ≥ 1000 cc, GVW < 3.5 t, 8 seats max.
- Medium PC ≥ 1000 cc, GVW 3.5 t, min 9 seats.
- Small commercial car ≥ 1000 cc, GVW < 2 t.
- Medium commercial car ≥ 1000 cc, 2 t ≤ GVW < 3.5 t.

REGULATORY BACKGROUND

Depending on the application, either EU or US-based emissions standards apply.

- Emissions standards for light-duty gasoline vehicles -> US/CARB standards. In 2009, South Korea adopted CARB's NMOG Fleet Average System (FAS) for gasoline-fueled vehicles. FAS allows car manufacturers to have a range of models with different emissions levels, while each OEM's fleet is required to meet a prescribed level of NMOG average. Standards are functionally equivalent to CARB's LEV, ULEV, SULEV and ZEV, respectively.
- Emissions standards for light-duty diesel vehicles -> EU standards. Since 2014 diesel vehicles are subject to Euro 6 regulations.
- K-OBD standards follow EU standards, but with specific OBD thresholds (see next page).

GASOLINE FUELED VEHICLES 2016 ONWARDS

Category		Dura-bility (km)	Exhaust emissions (g/km)			Evap (g/test)	Notes
			NMOG +NOx	CO	PM	HC	
K-LEV III	LEV160	15y/ 240k	0.100/0.087[1] /0.062[2]	2.61/5.97[1] / 2.0[2]	0.002 /0.006[1]	0.35 (2DD)	Cold CO 6.3 g/km K-LEVIII equivalent to USLEVIII
	ULEV125		0.078/0.075[1] /0.044[2]	1.31/5.97[1] / 2.0[2]			
	ULEV70		0.044/0.075[1] /0.044[2]	1.06/5.97[1] / 2.0[2]			
	ULEV50		0.031/0.075[1] /0.044[2]	1.06/5.97[1] / 2.0[2]			
	SULEV30		0.019/0.031[1] /0.012[1]	0.625/5.97[1] / 2.0[2]			
	SULEV20		0.0125/0.031[1] /0.012[1]	0.625/5.97[1] / 2.0[2]			
	ZEV		–	–	–	–	

1) for US06 mode.
2) for SC03 mode.

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 +NOx (g/km)	0.063	0.058	0.053	0.048	0.043	0.039	0.034	0.029	0.024	0.019
SFTP FAS[1)]	NMOG +NOx (g/km)	0.069	0.064	0.061	0.056	0.052	0.048	0.044	0.039	0.036	0.031
	CO (g/km)	2.61									

1) 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[1)]	Euro 6d[2)]
TA	01 Sep 2011	01 Sep 2014		01 Oct 2017	01 Jan 2020
FR	01 Sep 2013	01 Sep 2015	01 Sep 2018	01 Sep 2019	01 Jan 2021

1) WLTC mode and RDE NOx + PN.
2) Enforced RDE NOx + PN.

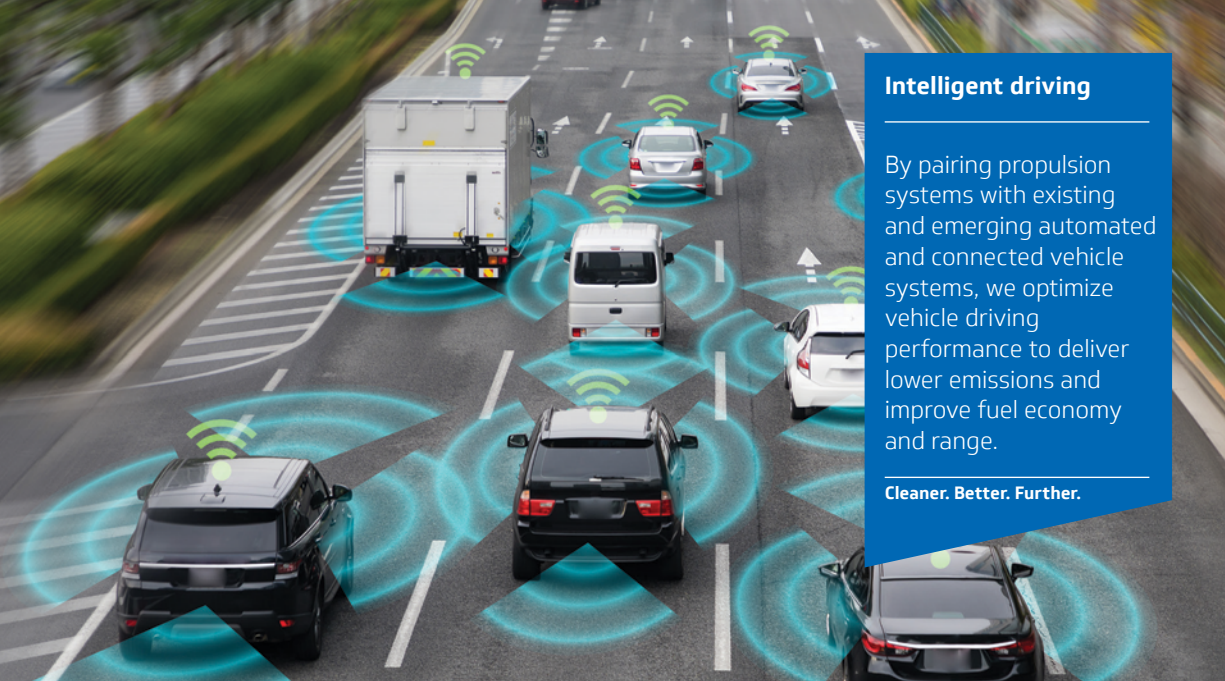
OTHER AREAS OF THE WORLD

Argentina	**Category**	**Standard**	**New models**	**All models**
	M1, N1	Euro 4	2009	2011
	M1 ≤ 2,500 kg GVW	Euro 5a	2015	2017
	M1 ≤ 2,500 kg GVW, N1	Euro 5a	2016	2018
Australia	M1 ≤ 3,500 kg	Euro 5a	Nov 2013	Nov 2016
Canada	MY 2017 onwards: Harmonization with the emission standards of the US EPA Tier 3 program. However differences exist in the phase-in of the standards: During the period of 2017-2020, manufacturers may choose alternative phase-in percentage schedules for PM and for evaporative emissions. CAFC: 8.6 l/100 km for PC (2010); 10.0 l/100 km for LTD (2010).			
Chile	MY 2005/2006 onwards, there are two alternative emissions compliance options: 1) US-based emission standards: EPA Tier 2 Bin 5 based standards effect. 2013/2014. 2) European-based emission standards: Euro 5 based standards effect. 2013/2014.			
Iceland	EU legislation applied			
Indonesia		**Standard**	**New models**	**All models**
		Euro 2	2005	2007

Mexico	Tier II (Euro 4 option) phase-in	
New Zealand	M1 ≤ 3,500 kg	Euro 5 (US and Japanese standards are alternatives)
Philippines	1/2016 onwards: All new passengers cars and LD vehicles: Euro 4 emission standards, subject to 50 ppm sulfur fuel availability (Administrative Order No. 2010-23)	
Russia	Euro 3 (ECE R83.05 Stage III)	2008
	Euro 4 (ECE R83.05 Stage IV)	2014
	Euro 5	2016
Saudi-Arabia	Euro 2	MY 2004
	Euro 3 (proposal) (UN ECE Reg 83/05)	TBD
South Africa	Euro 1	2/2005 (new models)
	Euro 2	2006 (new models), 2008 (all models)
Switzerland	Has harmonized national requirements on EU requirements	

OTHER AREAS OF THE WORLD

Thailand	Euro 4	2012 onwards		
Turkey	**Domestic vehicles**	**Standard**	**New models**	**All models**
	M1 Diesel	Euro 1	2001	2002
	M1 Gasoline	Euro 3, no OBD	2001	2002
	M1	Euro 4	2008	2009
	M1, N1 Class I	Euro 5	2010	2011
	N1 Class II, III	Euro 5	2012	2013
	Imported vehicles	Must comply with current EU standards		
Ukraine	Euro 6 (proposal)	2018		



Intelligent driving

By pairing propulsion systems with existing and emerging automated and connected vehicle systems, we optimize vehicle driving performance to deliver lower emissions and improve fuel economy and range.

Cleaner. Better. Further.

ONBOARD DIAGNOSTICS

EUROPEAN ON-BOARD DIAGNOSTICS

Euro 3-4

- It identifies malfunctions and deterioration that cause emissions to exceed thresholds, based on European revised urban + extra-urban cycle. Driver is notified upon detection.
- Onboard diagnostics was first introduced with Euro 3 emission limits (M1 ≤ 2.5 t GVW, N1 CL 1 type approval 1/2000, first registration 1/2001).
- No OBD Euro 4 step was foreseen.

EOBD Thresholds Euro 3-4 (g/km)	CO		HC		NOx		PM
	PI	CI	PI	CI	PI	CI	CI
M1 ≤ 2.5 t GVW, N1 CL 1	3.20	3.20	0.40	0.40	0.60	1.20	0.18
N1 CL 2	5.80	4.00	0.50	0.50	0.70	1.60	0.23
N1 CL3, M1 > 2.5 t GVW	7.30	4.80	0.60	0.60	0.80	1.90	0.28

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

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

EUROPEAN ON-BOARD DIAGNOSTICS

Euro 5 OBD requirements

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

Thresholds Euro 5 in mg/km	Implemen-tation	CO		NMHC		NOx		PM	
		PI	CI	PI	CI	PI	CI	PI [1]	CI [2]
M, N1 CL 1	TA 9/2009 FR 9/2011	1,900	1,900	250	320	300	540	50	50
N1 CL 2	TA 9/2010 FR 9/2012	3,400	2,400	330	360	375	705		
N1 CL 3, N2		4,300	2,800	400	400	410	840		

Expanded Monitoring area starting Euro 5
EGR system efficiency monitoring
EGR flow and cooler monitoring
Catalyst against NMHC [3]
Catalyst against NOx (> Euro 5+) [3] [4]
NOx aftertreatment device with or without reagent efficiency monitoring [3]
All O_2 Sensors to monitor catalyst (in addition to front sensor)
PM monitoring [3]
IUPR (> Euro 5+) [4]

- 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).

1) For GDI engines only.
2) 80 mg/km until 01 Sep 2011 for M and N vehicles with RM > 1,760 kg.
3) Mandatory total failure or removal detection if emission limit exceeded for DOC, DeNOx catalysts and DPF.
4) Euro 5+ OBD TA: 01 Sep 2011 / FR: 01 Jan 2014.

EUROPEAN ON-BOARD DIAGNOSTICS

Euro 6 OBD requirements

Thresholds	Implementation	CO		NMHC		NOx		PM	
Euro 6-1		PI	CI	PI	CI	PI	CI	PI	CI
M, N1 CL 1	TA 9/2014 FR 9/2015	1,900	1,750	170	290	150	180	25	25
N1 CL 2	TA 9/2015 FR 9/2016	3,400	2,200	225	320	190	220	25	25
N1 CL 3, N2		4,300	2,500	270	350	210	280	30	30
Euro 6-2		PI	CI	PI	CI	PI	CI	PI	CI
M, N1 CL 1	TA 9/2017 FR 9/2018	1,900	1,750	170	290	90	140	12	12
N1 CL 2	TA 9/2018 FR 9/2019	3,400	2,200	225	320	110	180	12	12
N1 CL 3, N2		4,300	2,500	270	350	120	220	12	12

Demonstration Cycle

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

EUROPEAN ON-BOARD DIAGNOSTICS

Additional requirement starting Euro 5+ [1]: In **U**se **P**erformance **R**atio monitoring **(IUPR)**

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

$$IUPR = \frac{Numerator_M}{Denominator_M}$$

$Numerator_M$ 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

	IUPR Euro 5a	IUPR Euro 5b	IUPR Euro 5b+	IUPR Euro 6b		IUPR Euro 6c/d		Comments
				PI	CI	PI	CI	Denominator
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 [2]	0.336	0.336 [2]	
Particulate filter	–	–	0.1 (only CI)	–	0.336 [2]	–	0.336 [2]	

1) Euro 5+ OBD TA: 01 Sep 2011 / FR: 01 Jan 2014.

2) Additional monitoring requirement of total failure or removal.

US ON-BOARD DIAGNOSTICS

EPA Tier III requirements are harmonized with CARB requirements (see page 50). Minor exceptions are outlined in the EPA section.

EPA OBD II—EPA HARMONIZATION FINAL RULE

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 0.040" hole.
EPA Tier III Comments	– EPA Tier III 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 CARB OBD II—ALL 2015+ MY VEHICLES (based on CARB OBD II rulemaking package—25 JUL 2016)

Monitor area	Condition for Malfunction
Engine Cooling System – Thermostat	a) Engine coolant temperature does not reach the following within Executive Officer approved time. – Within 20°C of normal operating temp (may use higher threshold if < 50% emissions increase). – Highest temp required by the OBD system to enable other monitors. b) 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, ECT at startup is 35°F less than malfunction threshold, or during conditions cause false results.
– Engine Coolant Temperature Sensor	– Must submit monitoring plan for systems that make use of more than one sensor to indicate engine temperature. – Circuit continuity and 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. NOTE: Feedback enable temp applies to stoichiometric feedback for (30% - MY'19, 60% - MY'20, 100% MY'21onw.) Manufacturer may choose non-stoich enable temp prior.

Monitor area	Condition for Malfunction
– Engine Coolant Temperature Sensor (contd.)	Diesel Engines – Manufacturer-defined (and Executive Officer approved) time limit. Note: may suspend/delay timer for conditions that could lead to false diagnosis. c) Stuck in range below the highest min enable temp required by other monitors. d) 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).
Crankcase Ventilation – Includes all CV-related external tubing/hoses	a) Disconnect of CV system between Crankcase and CV Valve and/or CV Valve and Intake Ducting. b) Leak in CV system (greater than the smallest internal hose cross-section) between Crankcase and CV Valve and/or CV Valve and Intake Ducting. Applicable for 20% of MY 2023, 50% of MY 2024, and 100% of MY 2025+ vehicles. Exemptions to a) and b) above may apply with Executive 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, when the disconnection or leak either causes the vehicle to stall, CV Design is integral to the induction system (no tubing, hoses, etc.). Engines certified on an engine dynamometer and having open CV system (vent to atmosphere): Monitoring plan to be provided for Executive Officer review/approval.
Comprehensive Components	– Monitoring required for any input or output component that can impact emissions (by any amount) 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. – Hybrid monitoring requires Exec Officer approval: Must monitor components that are emissions related and/or are used as inputs to OBD monitor(s). Exemption provided 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. – Exemption provided for hybrid electronic components use for inverter thermal management that are commanded solely by the driver.

US CARB OBD II – ALL VEHICLES

Monitor area	Condition for Malfunction
Comprehensive Components (contd.)	– Monitoring not required when both of the following are met for the component: – Components malfunctions cannot cause emissions to increase by: – PC/LDT SULEV II vehicles: 25% or more. – All other vehicles: 15% or more. – The component or system is not used as part of another diagnostic strategy.
– Input Components	a) Lack of circuit continuity or loss of communication (for digital inputs). b) Out of "normal" range. c) Irrational sensor value (2-sided monitoring). d) Components used for emission control strategies not specifically addressed by CARB regulations: – Failures that cause the strategy to not operate in its intended manner (delayed enable, erroneous exit, authority limit). e) Camshaft/Crankshaft Position Monitoring (for engines requiring precise cam/crank alignment and have sensors installed on both shafts): – Alignment malfunction of 1 (or more if no emissions impact) teeth: MY 2006-18 = VVT with belt/chain; MY 2019+ = VVT with or without belt/chain.
– Output Components	a) Improper functional response, as feasible. b) Circuit continuity faults. c) 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 any other monitor's enable Diesel Engines (d through h). d) Idle Control System: – Speed control cannot maintain within +/- 30% of target speed. – Speed control cannot maintain within the smallest engine speed tolerance range for any other monitor's enable. – 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).

Monitor area	Condition for Malfunction
– Output Components (contd.)	e) 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. f) "Wait to start" Lamp: failures that prevent illumination. g) Components used for emission control strategies not specifically addressed by CARB regulations: – Failures that cause the strategy to not operate in its intended manner (delayed enable, erroneous exit, authority limit). h) Tolerance Compensation: Improper compensation being applied by controller for connected hardware, with no monitoring required if < 15% emission increase AND < full useful life std. under test cycle (Executive Officer review/approval required).
In-Use Performance Ratio	Minimum performance ratios required: – 0.100 for high load purge flow (through MY2020). – 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 (MY2021+), and remainder. – 0.520 for low load purge flow, and evaporative 0.040" leak. Exceptions: – Plug-In Hybrid Vehicles: through 2019 MY, minimum ratio = 0.100 for those monitors requiring engine run operation. – Engine Certified MD Vehicles (2016-18 MY) as well as Chassis Certified LD, MD and Passenger Cars (2019-21 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: – Catalyst, exhaust gas sensors, evaporative 0.020" leak, EGR/VVT, secondary air system, NOx absorber, NMHC Catalyst, NOx Catalyst, PM Filter, boost pressure control, NMHC Catalyst and fuel system cylinder imbalance.

LEV III GASOLINE EMISSIONS THRESHOLDS

Exhaust Standards		Monitor Thresholds				Catalyst Monitor Thresholds
Vehicle Type	Vehicle Emission Category	NMOG +NOx Mult.[5]	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[2]	1.75
	ULEV70 / ULEV50	2.00				2.00
	SULEV30 / SULEV20[4]	2.50	2.50			2.50
Chassis Certified MDVs	All MDV	1.50	1.50	1.50[1]	17.50[3]	1.75

1) Applies to 2019 and subsequent MY vehicles not included in the phase-in of the PM standards set forth in Title 13, CCR section 1961.2 (a)(2)(B)2.
2) Applies to 2019 and subsequent MY vehicles.
3) Applies to 2019 and subsequent MY vehicles included in the phase-in of the PM standards set forth in Title 13, CCE section 1961.2 (a)(2)(B)2.
4) Manufacturer shall use the 2.5 times NMOG+NOx multiplier for vehicles not using the provision of section (e) (17.1.5).
5) Monitor threshold except catalyst.
Mult. = Multiplier to be used with the applicable standard (e.g. 2.0 times the NMOG+NOx standard).

US ON-BOARD DIAGNOSTICS

CARB allowing relaxed standards for Tier 2 / Tier 3 standards

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, 05 AUG 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, 05 AUG 2015)).

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[3]
Catalyst monitor	2.00	n.a.	n.a.	n.a.
Diesel				
Monitors[1]	1.85	1.50	2.00	n.a.
Aftertreatment monitors[2]	2.00	1.50[3]	2.00[3]	n.a.
PM filter performance monitor	1.85[3]	1.50[3]	n.a.	17.50

1) Applies to (f) (3.2.5), (f)(4)-(f)(7), (f)(9.2.2), (f)(12)-(f)(13).
2) Applies to (f) (1)-(f)(2), (f)(8), and (f)(9.2.4)(A).
3) Applies to MY '19 onwards.

US ON-BOARD DIAGNOSTICS

US CARB OBD II—GASOLINE VEHICLES

Monitor area	Condition for Malfunction
EGR (low + high flow rate) Sec. Air (low flow rate)	– For Non-LEVIII = 1.5 x std; For LEVIII = [1]. – 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-LEVIII vehicles = 1.5 x std (all constituents); for LEVIII = [1]. – RO2 Feedback Control: for Non-LEVIII vehicles = 1.5 x std (all constituents); for LEVIII = [1]. – A/F ratio for one (or more) cylinders different due to cylinder specific issue (e.g. fuel injector, individual cam lift, etc.). – For Non-LEVIII vehicles = 1.5 x std. – For LEVIII vehicles – LEV160, ULEV125, MD Chassis certified = [1] – ULEV50/70 = For 2014-2018 3x std; For 2019+ = [1] – SULEV 20/30 = For 2014-2018 4x std; For 2019+ = [1]. a) Control max. authority reached (if based on secondary oxygen sensor, allowed to also verify if control target achieved prior to failure). b) Fails to begin control within Exec. Officer approved time interval (based on manufacturer supplied data).
Misfire	Continuous monitoring for all pos. engine torque speeds/loads from 2nd crankshaft revolution after engine start /150 rpm below normal, warmed-up idle speed). – For non-LEVIII = 1.5 x std. (all constituents); For LEVIII = [1]. – 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 much occur in each 1,000 revolution block afterwards. – Misfire rate that causes catalyst temperature to reach damaging levels must be detected. Min. rate of 5%. – Engines with automated shut-off/restart strategies must get Exec. Officer approval for re-enabling conditions.

1) Refer to Gasoline Emission Thresholds (see page 58).

US CARB OBD II—GASOLINE VEHICLES

Monitor area	Condition for Malfunction
Evaporative System	a) 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% – MY2020, 100% – MY2021). – High load purge line that contribute < 1% of total mass flow on US06. b) Cumulative evaporative system leak ≥ 0.020'' orifice (may be revised upward for tank size > 25 gallons or < 1.5 x std. 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.
Exhaust Gas Sensors – (oxygen, A/F, NOx, PM, ..., incl Primary and Secondary)	a) Sensor Performance: – For Non-LEVIII = 1.5 x std. (all constituents); For LEVIII = [1]. – (Primary sensors only): symmetric and asymmetric delay to respond and response rates, lean-to-reach and rich-to-lean (certification data/analysis required). b) Lack of circuit continuity. c) Out of "normal" range. d) 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. e) Monitoring Capability: any characteristic no longer sufficient for use as input to other monitoring strategy. f) NOx activity (2022+ MY): Sensor not providing NOx data when normally feasible (isolation to root cause input component required, where applicable).
– Exhaust Gas Sensors Heaters	a) Current or voltage drop no longer within sensor manufacturer's limit for normal operation. b) Faults that result in conflict between command and actual state of the heater.

1) Refer to Gasoline Emission Thresholds (see page 58).

US CARB OBD II—GASOLINE VEHICLES

Monitor area	Condition for Malfunction						
Variable Valve Timing and/or Control	For Non-LEVIII = 1.5x std (all constituents); For LEVIII = [1] – Target error (outside crank angle and/or lift tolerance). – Slow response.						
Catalyst	**Affected Vehicles Certification**	NMOG	NOx	CO Mult.	PM Mult.	PM THD	NMHC Conversion Efficiency
	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	[1]					
	For threshold purposes, 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	a) Any single commanded element does not respond properly – by a robustly measurable amount; – in the commanded direction; – by an amount that is greater than otherwise would have been commanded without the cold start strategy activated. b) Deterioration – Non-LEVIII = 1.5 x std. (all constituents): LEVIII[1]; – Monitoring may apply to either individual cold start elements or the desired system effect.						
Heated Catalyst	Target heating temperature not reached within time limit. Limit based on 1.75 x std. (for non-LEVIII vehicles) ; for LEVIII =[1]. Alternate strategy requires Exec. Officer approval.						
Air Conditioning System	For non-LEVIII vehicles: 1.5 x std; for LEVIII = [1]. 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.						

1) Refer to Gasoline Emission Thresholds (see page 58).

US CARB OBD II—GASOLINE VEHICLES

Monitor area	Condition for Malfunction
Direct Ozone Reduction (DOR)	– Monitoring for non detectable ozone reduction required. For Non-LEVIII vehicles = NMOG ≤ 50%; For LEVIII vehicles = NMOG ≤ 5 mg/mi. – For Non-LEVIII vehicles with NMOG credit > 50%: monitoring for loss of NMOG performance > 50% NMOG standard. – For LEVIII vehicles with NMOG credit > 5 mg/mi: monitoring for loss of NMOG performance > 5 mg/mi. – DOR NMOG credit modifies malf. Criteria for other components (e.g. Malfunction Threshold = (1.5 x std. + DOR NMOG credit). Note: LEVIII std. combines NMOG+NOx.
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	Disablement allowed (with CARB approval) for: ambiant temperature < 20 F, altitude > 8,000 ft, vehicle speed > 82+ mph, fuel volume < 15% of capacity, battery voltage < 11V, battery voltage > manuf. Limit, during PTO operation, or tire pressure default action.

US CARB OBD II—DIESEL VEHICLES

Monitor area	Condition for Malfunction
Misfire	a) All Diesel Vehicles: one or more continuously misfiring cylinders. b) For all following vehicles: – All chassis certified Passenger Cars, LD Trucks and MDPVs with combustion sensor. – All 2010-2015 MY Medium Duty Vehicles with combustion sensor. – Phase-in for Chassis certified MDPVs: 20% of 2019 MY, 50% of 2020 MY, 100% of 2021+ MY. – For ALL OTHER MD VEHICLES: 100% of 2018+ MY vehicles. The following detection thresholds apply: – When misfire percentage is > 5% in each 1,000 engine revolution increment. – Threshold relief is possible for: – All engine certified MD vehicles: < 2.0 x NMHC, CO, NOx std. or 0.03 g/bhp-hr PM emission impact (with data evaluation). – Chassis Certified Passenger Cars, LD Trucks, MDPVs: Non-LEVIII = 1.5 x NMHC/CO/NOx stds. i=or 2.0 x PM std.; for LEVIII[1]. Misfire monitoring conditions – continuous monitoring as follows: – For Passenger Cars, LD Trucks, and Chassis Certified MDPVs – 2010 MY thru 2021 MY, engine certified MDPVs – 2010 MY thru 2018 MY, and all other vehicles not included in phase-in schedules below: – 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; Engine certified MDPVs – 20% of 2019 MY, 50% of 2020 MY, 100% of 2021 MY: – 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.

1) Refer to Diesel Emission Thresholds (see page 70).

US CARB OBD II—DIESEL VEHICLES

Monitor area	Condition for Malfunction
Particulate Matter System	a) Incomplete regenerate. b) Missing substrate. c) Active/intrusive injection.
Exhaust Gas Sensor Heater	Current or voltage outside manufacturer specification (requires CARB thresholds approval).
Feedback Control	Reductant injection, Fuel system, Exhaust gas sensors, Boost press., EGR, NOx absorber, PM system. Monitoring of proper feedback control to diagnose: a) Delayed entrance to feedback control. b) Failure or deterioration causes open loop or default operation. c) Feedback control adjustment at max. authority and unable to achieve target.
Cooling System; Crank-case Ventilation; Compre-hensive Components	Refer to OBD II requirements for ALL VEHICLES (top of CARD OBD II section).
Other Emission Related Components or Systems	Must request Executive Officer approval prior to introduction on a particular vehicle.
Exceptions to Monitoring Requirements	a) Emissions Thresholds may be modified by Executive Officer, dependent on upon most reliable monitoring method capabilities. b) PC/LDT SULEV II: Executive Officer shall approve Malf. Criterion of 2.5 x Std. in lieu of 1.5 x Std. Fed Bin 3 or 4: Use ULEV II NMOG & Co, with SULEV II NOx criteria. c) Engine cert. MDV: Executive Officer shall approve Malf. Criterion of (PM Std. +0.02) in lieu of 0.03. Additionally, (PM Std. +0.04) in lieu of 0.05. d) Disablement 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 PTO operation, or tire pressure default action.

US CARB OBD II—DIESEL VEHICLES

Monitor area	Condition for Malfunction
Exceptions to Monitoring Requirements (contd.)	e) Chassis Cert. 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 regen.). – Chassis certification: Non-LEVIII vehicles = 1.75 x NMHC std.; LEVIII[1]. – MVD Certified on Engine Dyno: 2.0 x (NMHC std. or NOx std.) + 0.2 g/bhp-hr.
– Other Aftertreatment Assistance Function	a) Exotherm Generation (PM filter regen. assistance): Catalyst unable to generate sufficient exotherm for regeneration. b) Feedgas Constituency (SCR assistance): catalyst unable to generate sufficient feedgas for proper SCR operation (Exemption if no malfunction results in: a) exceeding full useful life std AND b) increase in emissions of 25% for SULEV, 20% for ULEV, 30% for MDV engine dyno. Cert., or 15% for all others.). c) NMHC Conversion Downstream of PM Filter for use during regen.: No detectable amount of NMHC conversion. d) 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 and exemption conditions in b) met).
NOx Converting Catalyst – Conversion Efficiency	Chassis Certification: Non-LEVIII = 1.75 x std (NOx or NMHC); for LEVIII[1]. MDV Certified on Engine Dynamometer: – 2016 + MY: 2.0 x NMHC standard + 0.2 g/bhp-hr.
– Selective Catalytic Reduction (SCR)	a) Reductant delivery: (same emission thresholds as „Conversion Efficiency“ above). b) For reductant other than engine's fuel: – Insufficient reductant for proper operation – Improper reductant in reservoir/tank.
– Feedback Control	a) Fails to begin control within manufacturer defined time. b) Failure or deterioration causes open loop or default operation. c) Control max. authority reached and cannot achieve control target.

1) Refer to Diesel Emission Thresholds (see page 65).

US CARB OBD II—DIESEL VEHICLES (Applicable to Non-LEV III vehicles)

Monitor area	LDV and MDV (Chassis Cert.) Threshold					MDV (Engine Cert.) Threshold				
	MY	NMHC	CO	NOx	PM	MY	NMHC	CO	NOx	PM
NOx Absorber	2013+	1.75 x	–	1.75 x	–	2013+	2.0 x	–	+0.2	–
Exhaust Gas Sensor Performance – NOx and PM sensors	2013+	1.5 x	1.5 x	1.75 x	2.0 x	2013-2015	2.0 x	–	+0.3	–
– 2022+ MDV Engine Cert: NOx sensor activity		–	–	–	–	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(s) and/or output error (2013+ Monitor for desired effect as feasible)									
	2013+	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)

US CARB OBD II—DIESEL VEHICLES (Applicable to Non-LEV III vehicles)

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	2013-2021	–	–	–	1.75 x	2013+	2.0 x	2.0 x	–	0.03
						2022+	2.0 x	2.0 x	+0.2	0.03
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 Generation	2016+ MD vehicles	Unable to generate feedgas for proper SCR operation. Exemption if no malfunction results in: a) exceeding full useful life standard AND b) increase in emissions of 25% for SULEV, 20% for ULEV, 30% MDV engine dyno. cert., or 15% for all others.								
Aftertreatment Assistance Function	2010 + loss function (LEV III Proposal: Feedgas required 2015+)					2010 + loss function				

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

US CARB OBD II—DIESEL VEHICLES (Applicable to Non-LEV III vehicles)

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+	1.5x	1.5x	1.5x	2.0x	1.5x	1.5x	1.5x	0.03	2.0x	2.0x	+0.2	0.03
Fuel System Injection Quantity/Timing	2013+	1.5x	1.5x	1.5x	2.0x	Same Fault Criteria as Fuel System Pressure Control							
Fuel Control System using Tolerance compensation features	2015+MY	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+	1.5x	1.5x	1.75x	2.0x	2.5x	2.5x	2.5x	0.05	2.0x	2.0x	+0.2	0.03
Upstream Exhaust Gas Sensor Performance A/F Sensors	2013+	1.5x	1.5x	1.5x	2.0x	1.5x	1.5x	1.5x	0.03	2.0x	2.0x	+0.2	0.03
EGR Catalyst	2013+	No detectable amount of consistuent oxidation (monitoring not required for no measurable emission impact under any reasonable driving condition)											
EGR Low Flow, High Flow, Response Cooler Performance	2013+	–	–	–	–	1.5x	1.5x	1.5x	0.03	2.0x	2.0x	+0.2	0.03
Variable Valve Train Target Error Slow Response	2013+	–	–	–	–	1.5x	1.5x	1.5x	0.03	2.0x	2.0x	+0.2	0.03

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

LEV III OBD II DIESEL REQUIREMENTS

Exhaust Standards		Monitor Thresholds (except catalyst)[5]			Aftertreatment Monitor Thresholds[6]			DPF Filtering Performance Monitoring Threshold			
Vehicle Type	Vehicle Emission Category	NMOG+ NOx Mult.	CO Mult.	PM Mult.	NMOG+ NOx Mult.	CO Mult.[1]	PM Mult.	NMOG+ NOx Mult.	CO Mult.[2]	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[1]	1.50	1.50	n.a.	17.50
	ULEV70 / ULEV50	2.00			2.00			2.00			
	SULEV30 / SULEV20[4]	2.50	2.50		2.50	2.50		2.50	2.50		
MY 2016-18 Chassis Certified MDVs[7]	All MDV	1.50	1.50	2.0	1.75	n.a.	n.a.	n.a.	n.a.	1.75[2]	17.50[3]
MY 2019+ Chassis Certified MDVs[7]	All MDV			1.50[2] or 2.0[3]		1.5	1.50[2] or 2.0[3]	1.50	1.50	1.50[2]	17.50[3]

1) Applies to 2019 and subsequent MY.
2) 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.
3) 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.
4) Manufacturer shall use the 2.5 times NMOG + NOx multiplier for vehicles not using the provisions of section (f) (17.1.7).
5) Applies to (f)(3.2.5). (f)(4)-(f)(7). (f)(9.2.2). (f)(12)-(f)(13).
6) Applies to (f)(1)-(f)(2). (f)(8). And (f)(9.2.4)(A).
7) Except MDPVs.

INDIA ON-BOARD DIAGNOSTICS

Since 2010, all vehicles (except LPG or CNG-fuelled vehicles and those >3500 kg GVW until 2013, then all categories have been included) 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 (April 1, 2020) and to Euro 6-2 applied as 2nd phase (April 1, 2023).

BS VI – OBD – I (01 APR 2020)

Vehicle			CO		NMHC		NOx		PM	
Category	Class	Reference Mass (RM) – (kg)	mg/km							
			PI	CI	PI	CI	PI	CI	PI[1]	CI
M (M1 & M2)	–	All	1900	1750	170	290	150	180	25	25
N1	I	RM ≤ 1,305	1900	1750	170	290	150	180	25	25
	II	1,305 < RM ≤ 1,760	3400	2200	225	320	190	220	25	25
	III	RM > 1,760	4300	2500	270	350	210	280	30	30
N2	–	All	4300	2500	270	350	210	280	30	30

1) Applies only to direct injection positive ignition engines.

BS VI – OBD – II (01 APR 2023)

Vehicle			CO		NMHC		NOx		PM	
Category	Class	Reference Mass (RM) – (kg)	mg/km							
			PI	CI	PI	CI	PI	CI	PI[1]	CI
M (M1 & M2)	–	All	1900	1750	170	290	90	140	12	12
N1	I	RM ≤ 1,305	1900	1750	170	290	90	140	12	12
	II	1,305 < RM ≤ 1,760	3400	2200	225	320	110	180	12	12
	III	RM > 1,760	4300	2500	270	350	120	220	12	12
N2	–	All	4300	2500	270	350	120	220	12	12

The regulations BS VI-1 OBD and BS VI-2 OBD applies to categories M1, N1 Class I, N1 Class II, N1 Class III, and N2 with a reference mass not exceeding 2,610 kg.

If required by manufacturers, the LD regulation 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 1st April 2023, according to the requirements specified in AIS-137, BS VI $IUPR_M$ shall be greater or equal to 0.1 for all monitors M.

CHINA ON-BOARD DIAGNOSTICS

China 6 OBD gasoline requirements are based on CARB OBD II regulations with the following exceptions:

- 0.040" evaporative system leak monitor (0.020" detection not required, but optionally allowed).
- Air Fuel Ratio Cylinder Imbalance monitor not required.
- Asymmetric O2 response monitor not required (only symmetric is required).
- For cold start emission reduction strategy, the final deliver spark timing can be replaced with final command spark timing to detect the spark timing retard is correct.
- The requirement of misfire reporting logic within the first 1000 revolutions after engine start in CARB is not exist in China 6.

OTL DIESEL

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	

DIESEL

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

No IUPR individually track requirement for fuel system including gasoline and diesel.

BRAZIL ON-BOARD DIAGNOSTICS

	Requirements	Implementation	Vehicle mass	OBD emissions thresholds (g/km)				
				THC[1]	NMHC[2]	CO	NOx	PM
OBDBr-2	Continuity monitoring for main actuators and sensors Misfire, O_2 response, Cat monitoring diagnostics. O_2 response and cat mon required only in % ethanol ranges of 19-30% and 90-100% No Fuel system diagnostics	CY '14—'16	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 cat monitoring required in all % ethanol ranges New CO limit	CY '18 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, 06 FEB 2013)	CY '15 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.
1) THC for LPG vehicles.
2) NMHC for positive ignition vehicles except LPG.

BRAZIL ON-BOARD DIAGNOSTICS

	Requirements	Implementation	Vehicle mass	OBD Emissions Monitor Thresholds (g/km)[4]			OBD Emissions Catalyst Monitor Thresholds (g/km)
				NMOG + NOx	CO	PM[2]	NMOG + NO
OBDBr-3[1] PROCONVE L7	Unburned ethanol is not allowed to be deducted. Introduce NMOG + NOx Calculation.[3] 160.000 km durability. Malfunction codes should be kept for 400 days.	Jan 2022 onwards	Light-duty passenger	360	2000	36	480
			Light-duty commercial and Off Road	630	2500	36	840

1) 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.

2) Only applicable for GDI engines.
3) NMOG + NOX calculation based on CFR40.
4) Monitor threshold except catalyst.

BRAZIL ON-BOARD DIAGNOSTICS

	Requirements	Implementation	Vehicle mass	Level	OBD Emissions Monitor Thresholds (g/km)[4]		
					NMOG + NOx	CO	PM[2]
OBDBr-3[1] PROCONVE L8	Unburned ethanol is not allowed to be deducted. Introduce NMOG + NOx Calculation.[3] 160.000 km durability. Malfunction codes should be kept for 400 days.	Jan 2025 onwards	VLC > 1700 Kg	140	420	2000	18
				110	330	2000	18
			VLP / VLC ≤ 1700 kg	80	240	2000	18
				70	210	1500	18
				60	180	1500	18
				50	175	1500	18
				40	140	1250	18
				30	105	1250	12
				20	70	1000	12

1) 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.

2) Only applicable for GDI engines.
3) NMOG + NOX calculation based on CFR40.
4) Monitor threshold except catalyst.

BRAZIL ON-BOARD DIAGNOSTICS

OBDBr-3—GASOLINE VEHICLES

Monitor area	Condition for Malfunction
Catalysts Engine Misfire, O_2 Sensors	OBD Threshold on standard measured on FTP test For PROCONVE L7 and For PROCONVE L8 vehicles
EGR (low + high flow rate) Sec. Air (low flow rate)	PROCONVE L7 and PROCONVE L8 vehicles – 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	PROCONVE L7 vehicles (*extreme only); PROCONVE L8 vehicles ; * excess fuel when the vehicle is fueled with gasoline (E22-E30), or lack of fuel when fueled with hydrated ethanol (E90-E100)
Heated Catalyst	PROCONVE L7 and PROCONVE L8 vehicles – Heating temperature not reached within time limit.
Evaporative System	PROCONVE L8 vehicles; – Leakage equivalent to a 0.040" hole.
Exhaust Gas Sensors Primary and Secondary	PROCONVE L7 vehicles = (Primary sensors only): symmetric and asymmetric delay to respond and response rates, lean-to-reach and rich-to-lean (certification data/analysis required). PROCONVE L8 vehicles = a) Sensor Performance, b) Lack of circuit continuity, c) Out of "normal" range. d) 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 e) Monitoring Capability: any characteristic no longer sufficient for use as input to other monitoring strategy

BRAZIL ON-BOARD DIAGNOSTICS

OBDBr-3—GASOLINE VEHICLES

Monitor area	Condition for Malfunction
Fault Recording for 400 Days (Alternative)	PROCONVE L7 vehicles = - PID 0x93 = "Cumulative Continuous-MI Counter" of standards SAE J1979DA used in EURO VI Heavy Duty vehicles. PROCONVE L8 vehicles: Not yet decided, Still in discussion with governor.
Variable Valve Timing and/or Control	PROCONVE L8 vehicles; - Target error (outside crank angle and/or lift tolerance). - Slow response.
Cold Start Auxiliary System	PROCONVE L7 and PROCONVE L8 vehicles = - Monitoring may apply to either individual cold start elements when system is active.
In-Use Performance Ratio	Minimum performance ratios required: -0.100 for high load purge flow (through MY2020) -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 (MY2021+), and remainder -0.520 for low load purge flow, and evaporative 0.040" leak Exceptions: - Plug-In Hybrid Vehicles: through 2019 MY, minimum ratio = 0.100 for those monitors requiring engine run operation - Engine Certified MD Vehicles (2016-18 MY) as well as Chassis Certified LD, MD and Passenger Cars (2019-21 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: - Catalyst, exhaust gas sensors, evaporative 0.020" leak, EGR/VVT, secondary air system, NOx absorber, NMHC Catalyst, NOx Catalyst, PM Filter, boost pressure control, NMHC Catalyst, and fuel system cylinder imbalance.

BRAZIL ON-BOARD DIAGNOSTICS

OBDBr-3—GASOLINE VEHICLES

Monitor area	Condition for Malfunction
Crankcase Ventilation -Includes all CV-related external tubing/hoses	PROCONVE L8 vehicles; a) Disconnect of CV system between Crankcase and CV Valve and/or CV Valve and Intake Ducting b) 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 to a) and b) above may apply with Executive Officer Approval for Systems where vehicle operator is certain to respond or where disconnection or leak of an unmoni-tored 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 of disconnection , difficult to remove relative to connection between CV Valve and Intake, and not part of non-CV repair/maintenance - CV Valve and Intake, when the disconnection or leak either causes the vehicle to stall, CV Design is integral to the induction system (no tubing, hoses, etc.) Engines certified on an engine dynamometer and having open CV system (vent to atmosphere): Monitoring plan to be provided for Executive Officer review/approval
Exceptions to Monitoring Requirements	Disablement allowed (with CARB approval) for: ambiant temperature < 20 F, altitude > 8,000 ft, vehicle speed > 82+ mph, fuel volume < 15% of capacity, battery voltage < 11V, battery voltage > manuf. Limit, during PTO operation, or tire pressure default action

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.

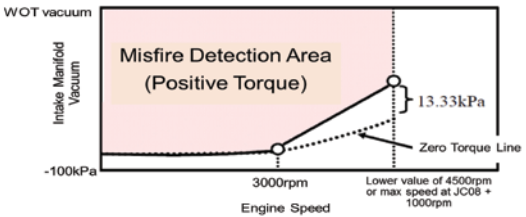
- 0.25 x JC08_Cold + 0.75 x JC08_Hot

	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 right figure. 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.

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		



Gasoline engine management system

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CO_2 EMISSIONS / FUEL ECONOMY

EUROPEAN UNION

EU REGULATION ON CO_2 EMISSION REDUCTION FOR PASSENGER CAR (M1) AND LIGHT COMMERCIAL VEHICLES (N1)

(EC) No. 443/2009 regulates the average specific emissions of CO_2 for each manufacturer for new passenger cars which are registered in the EU in each calendar year until 2024. (EC) No. 510/2011 regulates the same for light commercial vehicles. The community target for averaged CO_2 emissions (based on NEDC) from all combined new car fleets is: 130 g/km by 2015, 95 g/km by 2021 (with 95% fleet phase-in in 2020).

For LCV the target is: 175 g CO_2/km for 2015 and 147 g CO_2/km for 2020.

- (EC) 443/2009 regulation is complemented by additional measures to deliver a further 10 g/km reduction (tires pressure monitoring and resistance, efficiency improvements for air conditioning, gear shift indicator, use of bio fuels).
- Eco-innovation credit:
  Innovative CO_2 reducing technologies (called eco-innovations) are technologies not included in test cycle CO_2 measurement, nor included in complementary measures. Total contribution of eco-innovation limited to max 7 g CO_2/km per year in each manufacturer's average specific target.
- Super-credit:
  When calculating manufacturer's fleet average, passenger cars with emissions below 50 g CO_2/km get the following higher weight: 2 in 2020, 1.67 in 2021, 1.33 in 2022, 1 in 2023 onwards. This reduction combined over the 2020-2022 period is limited to 7.5 g CO_2/km.
  For LCV fleet average, vehicle with emissions below 50 g CO_2/km get the following higher weight: 1.5 in 2017, 1 in 2018 onwards.

Each manufacturer has individual target based on average mass of their EU passenger car and LCV fleets, based on CO_2 emission limit curves as defined on the next page. The manufacturer CO_2 emission fleet average for passenger cars is computed, considering 100% of fleet from 2015 to 2019, 95% in 2020 for passenger cars, and 100% by Jan 2021. For light commercial vehicles the fleet average is computed considering 100% from 2017 onwards.

If the manufacturer's averaged CO_2 is above its specific target, an excess emissions penalty applies. The annual premium is based on the number of g/km above the curve multiplied by the number of vehicles sold during the year by the manufacturer.

- From 2012-2018: 5 € for 1st g; 15 € for 2nd g; 25 € for 3rd g; 95 € 4th g onwards exceeding the target (per vehicle sold).
- From 2019: 95 €/g exceeding the target (per vehicle sold).

WLTP was introduced in Sept 2017 to replace the NEDC. From 2017 to 2020, the CO_2MPASS correlation tool is used to transpose CO_2 emissions measured on WLTC into NEDC values that are used to evaluate the manufacturers performance in regards to its CO_2 target, and to calculate possible excess emissions premium.In 2020 the CO_2 emissions of all new vehicles will be determined with both NEDC and WLTP, in order to set the specific emission target for 2021.

EUROPEAN UNION

CO_2 EMISSION LIMIT CURVES

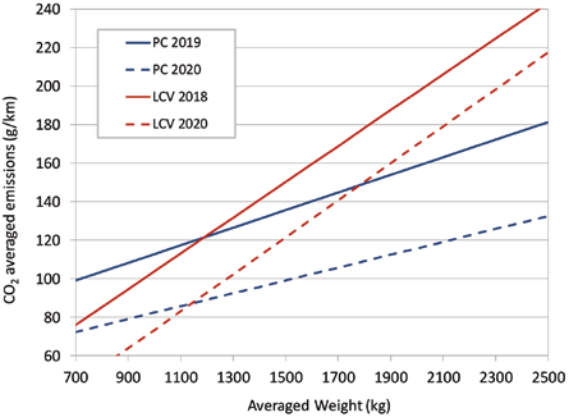
The CO_2 emission limit varies as a function of the vehicle mass. The curves are defined by the following formula:

$$CO_2 = \text{Target} + a \times (M - M0)$$

The parameters of the formula are defined in the table below. The reference mass M0 is based on the European fleet averaged mass of three previous years.

Each manufacturer fleet averaged mass M is computed every year. From the CO_2 emission limit curve the manufacturer get its fleet average target for CO_2 emission.

Vehicle type	Years	a	Target	M0
		g/km / kg	g/km	kg
Passenger Cars	2012-2015	0.0457	130	1372
	2016-2018	0.0457	130	1392.4
	2019	0.0457	130	1379.88
	2020	0.0333	95	1379.88
Light Commercial Vehicles	2014-2017	0.093	175	1706
	2018	0.093	175	1766.4
	2020	0.096	147	1766.4



CO_2 emission limit curves for Passenger Cars and Light Commercial Vehicles.

EUROPEAN UNION

CO_2 FLEET TARGET 2021 TO 2024

Starting 2021, manufacturers will have individual CO_2 reference target based and measured on WLTP adapted to 14°C.
The reference target is calculated from the manufacturer's target fulfillment obtained in 2020 based on NEDC, and from its CO_2 performance obtained in 2020 with the WLTP, as follows:

$$WLTP_{ref.target} = WLTP_{2020\_CO2} * \left(\frac{NEDC_{2020target}}{NEDC_{2020\_CO2}} \right)$$

Where:
$WLTP_{2020\_CO2}$ is the averaged CO_2 emissions in 2020 obtained on WLTP,
$NEDC_{2020\ target}$ is the 2020 fleet specific emission target of the OEM,
$NEDC_{2020\_CO2}$ is the averaged CO_2 emissions in 2020 calculated on NEDC.

The specific emission target for a manufacturer is calculated as follows:

Specific emission target = $WLTP_{reference\ target}$ + a [(Mø - M_0) - (M$ø_{2020}$ - $M_{0,2020}$)]

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 mass as 2020.
$M_{0,2020}$ is the reference mass for 2020 defined in table on previous page,
Mø is the manufacturer's averaged mass in the specific calendar year,
M$ø_{2020}$ is the manufacturer's averaged mass registered in 2020.

EUROPEAN UNION

CO_2 FLEET TARGETS 2025 TO 2029 AND 2030

On 17 April 2019 the regulation (EU) 2019/631 was adopted setting CO_2 emission performance stand-ards for new passenger cars and for new light commercial vehicles, and repealing regulations (EC) No. 443/2009 and (EC) No. 510/2011, with application from 1 January 2020.

The targets are a reduction relative to 2021 baseline of:

- 15% in 2025 and 37.5% in 2030 for passenger cars.
- 15% in 2025 and 31% in 2030 for light commercial vehicles.

A CO_2 reference value for 2021 is calculated for each OEM, as follows:

$$\text{Reference value}_{2021}\,(i) = \text{WLTP}_{2020\_CO2\,measured} \cdot \left(\frac{\text{NEDC}_{2020\,fleet\,target}}{\text{NEDC}_{2020\_CO2}}\right) + a \cdot (M_{ø2021} - M_{0,2021})$$

Where:
$WLTP_{2020\_CO2\_measured}$ is the averaged CO_2 emission measured by the OEM in 2020,
NEDC2020 fleet target is 95 g CO_2/km for PC; 147 g CO_2/km for LCV,
a is the coefficient 0.0333 for PC; 0.096 for LCV,
$M_{ø2021}$ 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.

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

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

Where:
N(i) is the number of vehicles sold by OEM (i) in 2021,
$\text{reduction factor}_{2025}$ = 0.15,
$\text{reduction factor}_{2030}$ = 0.375 for PC; 0.31 for LCV.

EUROPEAN UNION

CO_2 FLEET TARGETS 2025 TO 2029 AND 2030

From 2025 the specific emission target of each OEM is calculated as follows:

$$\text{Specific emissions reference target}_{2025/2030} = \text{EU Fleet wide target}_{2025/2030} \cdot (TM - TM_0)$$

Where:
TM is the manufacturer's averaged test mass of vehicles sold in the calendar year, TM_0 is the EU averaged test mass of all vehicles registered in the calendar year.

The coefficient $a_{2025/2030}$ is defined as:

$$a_{2025/2030} = a_{2021} \cdot \frac{\text{EU Fleet wide target}_{2025/2030}}{\text{Average emissions}_{2021}}$$

a_{2021} is the slope of CO_2 emissions versus test mass of all vehicles registered in 2021 in the EU.

From 2025, each OEM's fleet averaged CO_2 emission has to remain below its specific emissions target defined by the following formula. In case of exceedance, the OEM will have to pay an excess emission premium of 95 Eur per exceeded g CO_2/km times the number of vehicles sold in the year.

$$\text{Specific emissions target}_{2025/2030} = \text{Specific emissions reference target}_{2025/2030} \cdot \text{ZLEV Factor}$$

The ZLEV factor has a max value of 1.05 and a min value of 1.0 and is defined as 1+y-x. The parameter y takes into consideration the share of low (< 50 g CO_2/km) and zero emissions vehicles in the fleet according to a specific formula based on actual CO_2 emission of the vehicle. x is the benchmark for low and zero emission vehicles sales target, set at 15% for the years 2025 to 2029, and 35% for PC and 30% for LCV for the years 2030 onwards.

US

The US has 2 sets of parallel standards:

1. CAFE – Corporate average standards adopted by NHTSA.

HISTORY

- CAFE standards were first adopted in 1975 and nearly doubled fleet average fuel economy standards by 1985. CAFE standards remained in force but targets stagnated through 2010.
- The Energy Independence and Security Act (EISA) passed in 2007 mandating a 40% increase in fuel economy in the next decades. In a parallel development in 2007, the US Supreme Court ruled CO_2 as a pollutant under the Clean Air Act (CAA).
- EPA and NHTSA finalized in April 2010 new harmonized CAFE and GHG Rules for MY 2012-16 Light Duty vehicles.
- In August 2012, EPA and NHTSA issued joint final rules extending the harmonized GHG and Fuel Economy standards for MY 2017-25 vehicles.
- EPA made a regulatory commitment to conduct a Mid Term Evaluation (MTE) for longer term standards for MY 2022-25 and decide if they are still appropriate given the latest available date and information. EPA completed the MTE in April 2018 with a determination to revise the MY 2022-25 standards. In August, 2018, EPA and NHTSA proposed relaxed standards in the "Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks". The final rule has not been published as of the time of the printing of this booklet.
- Under CAFE, manufacturers could pay fees instead of meeting standards. Under the Clean Air Act manufacturers must comply with CO_2 standards and cannot pay non compliance fees. EPA established a Temporary Lead-Time Allowance Alternative Standards (TLAAS) for additional transition time.

2012-2016 STANDARDS

Standards are based on CO_2 emissions-footprint curves, where each vehicle has a different CO_2 emissions compliance target depending on its "footprint" value, related to the size of the vehicle. The table below provides representative CO_2 and fuel economy requirements computed based on average footprints with a vehicle fleet comprising 67% passenger cars and 33% light duty trucks.

Projected 2012-16 fleet-wide CO_2 and fuel economy compliance levels

Vehicle Category & Standard		Model Year				
		2012	2013	2014	2015	2016
Passenger Cars	CO_2 g/mi	263	256	247	236	225
	Fuel eco. (mpg)[1]	33.8	34.7	36.0	37.7	39.5
Light Duty Trucks	CO_2 g/mi	346	337	326	312	298
	Fuel eco. (mpg)[1]	25.7	26.4	27.3	28.5	29.8
Combined Cars & Trucks	CO_2 g/mi	295	286	276	263	250
	Fuel eco. (mpg)[1]	30.1	31.1	32.2	33.8	35.5

Standards applicable to the fleet of PC, LDT and MDPV with GVWR ≤ 10,000 lbs sold by a manufacturer within the US. CO_2 emissions are tested over the EPA 2-cycle test (FTP-75 + HWFET).

1) Projected fuel economy required before credits and incentives.

US

N_2O and CH_4 Standards. In addition to the fleet-average CO_2 emission targets, the rule also includes emission caps for tailpipe nitrous oxide and methane emissions (FTP-75). – N_2O: 0.010 g/mile. – CH_4: 0.030 g/mile.

Flexibilities: The regulation also includes a system of Averaging, Banking and Trading (ABT) of credits, based on a manufacturer's fleet average CO_2 performance. Credit trading is allowed among all vehicles a manufacturer produces, both cars and light trucks, as well as between companies.

The regulation includes ABT of fleet average CO_2 credits and the air conditioning improvement credits, both programs carried over from the 2012-16 rule.

The regulation also includes targeted incentives to encourage early introduction of advanced technologies, including:

- Incentives for electric, plug-in hybrid electric and fuel cells vehicles.
- Incentives for hybrid technologies for large pickups and for other technologies that achieve high fuel economy levels on large pickups.
- Incentives for natural gas vehicles.
- Credits for technologies with potential to achieve real world greenhouse gas reductions and fuel economy improvements that are not captured by the standards test procedures.

2017-2025 STANDARDS (per 2012 regulations)

Standards are based on CO_2 emissions-footprint curves, where each vehicle has a different CO_2 emissions compliance target depending on its 'footprint' value, related to the size of the vehicle. The following table provides representative CO_2 and fuel economy requirements computed based on average footprints with a vehicle fleet comprising 67% passenger cars and 33% light duty trucks.

Projected 2017-25 fleet-wide CO_2 and fuel economy compliance levels

Vehicle Category & Standard		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
	Fuel eco. (mpg)[1]	41.9	44.0	46.5	48.8	51.7	54.2	56.6	59.3	62.2
Light Duty Trucks	CO_2 g/mi	295	285	277	269	249	237	225	214	203
	CO_2 equiv. mpg	30.1	31.2	32.1	33.0	35.7	37.5	39.5	41.5	43.8
Combined Cars & Trucks	CO_2 g/mi	243	232	222	213	199	190	180	171	163
	CO_2 equiv. mpg	36.6	38.3	40.0	41.7	44.7	46.8	49.4	52.0	54.5

Mid Term Evaluation: EPA completed the MTE in April 2018 with a determination to revise the MY 2022-25 standards. In August, 2018, EPA and NHTSA proposed relaxed standards in the "Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks". The final rule has not been published as of the time of the printing of this booklet.

1) Projected fuel economy required before credits and incentives.

CALIFORNIA

HISTORY

- California led development of regulation to control green house gases (GHG). First passed in 2002, regulations became effective in January 2006 and phase in from 2009-2016.
- In 2010 California adopted regulations such that cars that complying to Federal 2012-2016 also comply with CARB standards.
- The rule issued by NHTSA and EPA in 2010 harmonized EPA and CARB GHG regulations from 2017-2025 to the values shown on the previous page.
- The determination to revise the US Federal standards for 2021-2025 did not affect CARB standards. However, EPA issued a rule effective November, 2019 withdrawing the waiver allowing California the ability to regulate GHG. California in conjunction with 23 other states subsequently filed a law-suit against the EPA challenging their ruling. That lawsuit is still ongoing at the time of publication

California fleet average GHG emission standards				
Year	GHG Standard, g CO_2/mi (g CO_2/km)		CAFE Equivalent, mpg (l/100 km)	
	PC/LDT1	LDT2	PC/LDT1	LDT2
2009	323 (201)	439 (274)	27.6 (8.52)	20.3 (11.59)
2010	301 (188)	420 (262)	29.6 (7.95)	21.2 (11.10)
2011	267 (166)	390 (243)	33.3 (7.06)	22.8 (10.32)
2012	233 (146)	361 (225)	38.2 (6.16)	24.7 (9.52)
2013	227 (142)	355 (221)	39.2 (6.00)	25.1 (9.37)
2014	222 (138)	350 (218)	40.1 (5.87)	25.4 (9.26)
2015	213 (133)	341 (213)	41.8 (5.63)	26.1 (9.01)
2016	205 (128)	332 (207)	43.4 (5.42)	26.8 (8.78)

SOUTH KOREA

	2012	2016	2017	2018	2019	2020
FC in km/l	≥17	24.3 km/l phase-in 10%/20%/30%/60%/100% by 2020				
GHG in g/km	≤140	97 g/km phase-in 10%/20%/30%/60%/100% by 2020				

Government will evaluate coast down data through real road test.

TAIWAN

Fuel economy standards for PC, LDT ≤ 2,500 kg.

Class of Vehicle (kg)	Under FTP 75	Under EU Dir 199/100
< 1,200	16.2	14.1
1,200-1,800	13.0	11.3
1,800-2,400	11.4	9.9
2,400-3,000	10.0	8.7
3,000-3,600	9.2	8.0
3,600-4,200	8.5	7.4
4,200-5,400	7.2	6.3
> 5,400	6.5	5.7

Global Fuel Economy Initiative (GFEI): "50 by 50"

Initiative jointly launched by UNEP (UN Environment Program), IEA (International Energy Agency), ITS (International Transport Forum), FIA Foundation. Call for cars worldwide to be made 50% more fuel efficient by 2050, along with interim targets.

INDIA

The Indian fuel consumption standard is based on CAFC system. It applies to petrol, diesel, LPG, CNG and electrical, at least four wheels passenger cars with up to nine seats including driver's seat and with a GVW ≤ 3,500 kg.

The limits are computed from the weighted average unladen mass (W), in kg, of the fleet that manufacturers sell in a given year, calculated as:

$$W = \sum N_i W_i / \sum N_i$$

N_i being the number of vehicles manufactured or imported for sale in India of a model i in the respective fiscal year.

Year	Test Cycle	Average Fuel Consumption Standard (petrol equivalent liter per 100 km)
Fiscal year from 2017/18 to 2021/22	NEDC	0.0024 x (W - 1037) + 5.4922
Fiscal year from 2022/23 onwards	NEDC	0.002 x (W - 1145[1]) + 4.7694

Average of Actual Fuel Consumption (AAFC) in petrol equivalent liter per 100 km for a manufacturer is the weighted average fuel consumption of all manufactured or imported vehicles in a fiscal year. Since the 1st April, 2017 onwards, it has to be less than or equal to Average Fuel Consumption Standard of the respective fiscal year. AAFC shall be determined as:

$$AAFC = \sum K_i N_i FC_i / \sum N_i$$

Where N_i has been already defined, K_i is the equivalent vehicle credits for electric vehicles and FC_i the petrol equivalent fuel consumption (liter/100 km) of a model i.

The CO_2 (g/km) measured over the NEDC cycle, multiplied by a factor taking into account the fuel type, gives the actual fuel consumption FC (in liter/100 km for petrol, diesel and LPG, in kg per 100 km in case of CNG). For electricity driven model, FC shall be measured in kWh/100 km.

The actual fuel consumption in petrol equivalent (FC_i) for diesel, LPG, CNG and electricity vehicles shall be obtained by multiplying the actual fuel consumption (FC) with the petrol equivalent conversion factors.

Type of fuel	FC (l/100km for petrol, LPG and diesel, kg/100km for CNG)	Conversion Factor to Petrol equivalent
Petrol	0.04217 x CO_2	–
Diesel	0.03776 x CO_2	1.1168
LPG	0.06150 x CO_2	0.6857
CNG	0.03647 x CO_2	1.1563
Electricity	–	0.1028

1) The Central Government may, by notification, in consultation with the Bureau of Energy Efficiency, revise this coefficient 'b' if W<1145 kg during the calendar year 1st January, 2016 to 31st December, 2016. In that case, the average unladen mass of all the vehicles in the said period will be the value of 'b'.

PR OF CHINA

PASSENGER CARS

- Passenger car standards apply to both individual vehicles, evaluated against the weight-based standard limit fuel consumption (FC), and a Corporate Average Fuel Consumption (CAFC) target.
- Vehicle makers (VM) with a CAFC above the target face penalties.
- Governmental target to reduce CAFC to ~ 5 l/100 km (equivalent to 120 g CO_2/km) in 2020.
- NEV credit system can be used toward 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 VM vehicle type,
T_i = vehicle fuel consumption target of single type 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 type of vehicle i.

China Corporate Average Fuel Consumption (CAFC)								
GB 27999-2011 CAFC I CAFC target= 7 L/100 km				GB 27999-2014 CAFC II CAFC target= 5 L/100 km				
2012	2013	2014	2015	2016	2017	2018	2019	2020
109%	106%	103%	100%	134%	128%	120%	110%	100%

China Fuel Consumption Limits for Passenger Cars, in l/100 km						
Curb Mass (CM), kg	GB 19578–2004 FC II 1/2008–1/2016		GB 19578–2014 FC III 1/2016–		CAFC II target	
	M/T	A/T[1]	M/T	A/T[1]	M/T[2]	A/T[1]
CM ≤ 750	6.2	6.6	5.2	5.6	4.3	4.5
750 < CM ≤ 865	6.5	6.9	5.5	5.9	4.3	4.5
865 < CM ≤ 980	7	7.4	5.8	6.2	4.3	4.5
980 < CM ≤1,090	7.5	8	6.1	6.5	4.5	4.7
1,090 < CM ≤ 1,205	8.1	8.6	6.5	6.8	4.7	4.9
1,205 < CM ≤ 1,320	8.6	9.1	6.9	7.2	4.9	5.1
1,320 < CM ≤ 1,430	9.2	9.8	7.3	7.6	5.1	5.3
1,430 < CM ≤ 1,540	9.7	10.3	7.7	8	5.3	5.5
1,540 < CM ≤ 1,660	10.2	10.8	8.1	8.4	5.5	5.7
1,660 < CM ≤ 1,770	10.7	11.3	8.5	8.8	5.7	5.9
1,770 < CM ≤ 1,880	11.1	11.8	8.9	9.2	5.9	6.1
1,880 < CM ≤ 2,000	11.5	12.2	9.3	9.6	6.2	6.4
2,000 < CM ≤ 2,110	11.9	12.6	9.7	10.1	6.4	6.6
2,110 < CM ≤ 2,280	12.3	13	10.1	10.6	6.6	6.8
2,280 < CM ≤ 2,510	13.1	13.9	10.8	11.2	7	7.2
2,510 < CM	13.9	14.7	11.5	11.9	7.3	7.5

1) Or ≥ 3 rows of seats.

2) And < 3 rows of seats.

PR OF CHINA

LIGHT DUTY COMMERCIAL VEHICLES (GB 20997-2015)

Applicable for N1 and M2 vehicles (GVW ≤ 3,500 kg)
Phase 1: 1/2009 for vehicles in production (certified before 2/2008)

Phase 3: N1 and M2 vehicles (GVW ≤ 3,500 kg)				
Curb Mass (CM), kg	N1 Vehicles		M2 Vehicles	
	Gasoline (l/km)	Diesel (l/km)	Gasoline (l/km)	Diesel (l/km)
CM ≤ 750	5.5	5	5	4.7
750 < CM ≤ 865	5.8	5.2	5.4	5
865 < CM ≤ 980	6.1	5.5	5.8	5.3
980 < CM ≤1,090	6.4	5.8	6.2	5.6
1,090 < CM ≤ 1,205	6.7	6.1	6.6	5.9
1,205 < CM ≤ 1,320	7.1	6.4	7	6.2
1,320 < CM ≤ 1,430	7.5	6.7	7.4	6.5
1,430 < CM ≤ 1,540	7.9	7	7.8	6.8
1,540 < CM ≤ 1,660	8.3	7.3	8.2	7.1
1,660 < CM ≤ 1,770	8.7	7.6	8.6	7.4
1,770 < CM ≤ 1,880	9.1	7.9	9	7.7
1,880 < CM ≤ 2,000	9.6	8.3	9.5	8
2,000 < CM ≤ 2,110	10.1	8.7	10	8.4
2,110 < CM ≤ 2,280	10.6	9.1	10.5	8.8
2,280 < CM ≤ 2,510	11.1	9.5	11	9.2
2,510 < CM	11.7	10	11.5	9.6

JAPAN

2015 FUEL ECONOMY FOR ALL FUELS

Regulation considers diesel and gasoline vehicles together.
Test cycle: JC08 (cold and hot), applicable from Mar 2013.

Vehicle Class	2004 Avg value – km/l	2015 Avg value – km/l	Change %
PC	13.6	16.8	23.5
Small buses	8.3	8.9	7.2
LCV	13.5	15.2	12.6

Other requirements:

- CAFE will be introduced to encourage further FE improvement.
- Test cycle: combined JC08
  (FE JC08 total = 1 / (0.25/FE JC08cold + 0.75/FE JC08hot).
- Diesel FE = FE JC08 total / 1.1.
- LPG FE = FE JC08 total / 0.78.

Gasoline Passenger Cars – Targets for 2015								
Ref. mass (kg)	≤ 600	601 - 740	741 - 855	856 - 970	971 - 1,080	1,081 - 1,195	1,195 - 1,310	1,311 - 1,420
km/l	22.5	21.8	21.0	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

Gasoline Passenger Cars – Targets for 2020								
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	19.0	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	

JAPAN

FUEL CONSUMPTION - CO_2 EMISSIONS

Regulation considers diesel and gasoline vehicles together.
Test cycle: JC08 (cold and hot), applicable from Mar 2013.

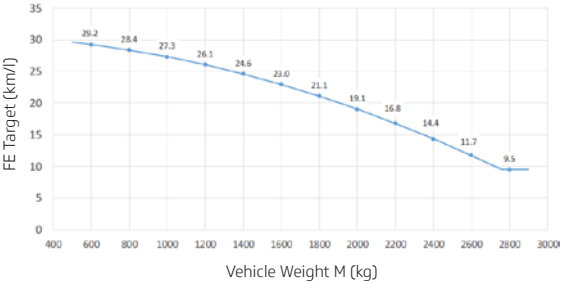
- Vehicle: ICE, HEV, PHEV, EV
- Number of passengers: Less than or equal to 9 people

OR more than or equal to 10 people and weight less than 3.5t

- Fuel: gasoline, diesel and LPG
- Test Cycle: WLTC
- Diesel FE = WLTC FE / 1.1
- LPG FE = WLTC FE / 0.78
- EV FE = 6750 / EC
- EC: AC power consumption (Wh/km)
- PHEV FE =

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

2030 FE Target



M: below 2,759kg

FE= $-2.47\times10^{-6}\times M^2-8.52\times10^{-4}\times M+30.65$

M: above 2,759kg

FE= 9.5

BRAZIL

NEW BRAZILIAN AUTOMOTIVE POLICY

- New car classification to compare its emission levels of pollutants, in addition to traditional parameters such as choice of makes and models, power consumption and fuel type.

The criteria are based on all models of light vehicles with PROCONVE L5 approved and it is granted to 5 stars green as the sum of the following criteria:

For low emissions of conventional pollutants (CO, NOx and NMHC):

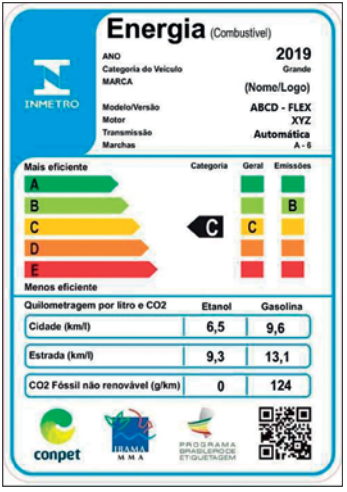
- Model level between 80% and limit = 1 star.
- Model level between 60% and 80% limit = 2 stars.
- Model level below the 60% threshold = 3 stars.

Level of CO_2 emissions, calculated from the value of approved issuing, discounting the portion "ethanol" (17.7% to 100% for E22 and E100) and, in case of alcohol or flex vehicles, making up an average between the issue with E22 and E100:

- Below 80 g/km = 1 star.

Fuel used:

- Renewable fuel vehicle (flex or dedicated), hybrid or electric = 1 star.



BRAZIL

FUEL CONSUMPTION CALCULATIONS – BASICS

1a Measure E20 + E100 Urban cycle / City cycle / EPA75 = (norm ABNT NBR 6601).
1b Measure E20 + E100 Highway cycle (norm ABNT NBR 7024).
2 Calculated final fuel consumption = measured fuel consumption x factor (Portaria n 377).
3 Calculated combined fuel consumption for E20 and E100 = 55% Urban + 45% Highway.
4 Calculated energetic E20 and E100 fuel consumption in MJ/km based on MJ/kg:

Physical Characteristics	Unit	E00	E22	E100	Unit	GNV
Calorific Power	MJ/kg	43.06	38.92	24.8	MJ/kg	48.74
Density	kg/l	0.735	0.745	–	kg/Nm^2	0.723
Energy Density	MJ/l	31.65	28.99	–	MJ/Nm^3	35.24

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

PBE classification	Energetic Consumption EC – (MJ/kg)			
	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

Diesel engine management systems

Precision ultra-high pressure fuel injection systems for low emissions and improved fuel economy on commercial vehicle applications up to 18 liter engines.

Cleaner. Better. Further.

REFERENCE FUELS

EU REGULATION 2008/692/EC

UNLEADED GASOLINE TEST FUEL: PETROL E5 / E10

Currently E5 and E10 serve as reference fuels. The use of E10 will be mandatory for new types as of 01 Mar 2016 and for all types 01 Aug 2018.

Parameter	Unit	Limits E5	Limits E10
Octane	RON/MON	≥ 95/85	≥ 95/85 ≤ 98/89
Vapour Pressure	kPa	56-60[1]	
Density at 15°C	kg/m³	743-756	
Distillation at 70°C	% vol	24-44	34-46
Distillation at 100°C	% vol	48-60	54-62
Distillation at 150°C	% vol	82-90	86-94
Final Boiling Point	°C	190-210	170-195
Aromatics	% vol	29-35	25-32
Olefins	% vol	3-13	6-13
Benzene	% vol	≤1	
Oxygen (ethanol only)	% mass	Report	3.3-3.7
Sulfur	mg/kg	≤ 10	
Lead	mg/l	≤ 5	
Phosphorus	mg/l	≤ 1.3	
Ethanol[2]	% vol	4.7-5.3	9-10
Water	%(v/v)	≤ 0.015	≤ 0.05
Induction period	minutes	> 480	
Existent gum	mg/ml	< 0.04	
Copper corrosion	–	Class 1	

DIESEL TEST FUEL: DIESEL B5 / B7

Parameter	Unit	Limits B5	Limits B7
Cetane Number		52-54	52-56
Cetane Index			≥ 46
Density at 15°C	kg/m³	833-837	
Distillation at T50	°C	≥ 245	
Distillation at T95	°C	345-350	345-360
Final Boiling Point	°C	≤ 370	
Flashpoint	°C	≥ 55	
Viscosity at 40°C	mm²/s	2.3-3.3	
Polycyclic aromatics	% mass	2.0-6.0	2.0-4.0
Sulfur	mg/kg	≤ 10	
Total contamination	mg/kg		24
Water content	mg/kg	≤ 200	
FAME[3]	% vol	4.5-5.5	6.0-7.0
Oxidation stability[4]	mg/ml	≤ 0.025	
Oxidation stability at 110°C	hr	≥ 20	
Copper corrosion	–	Class 1	
Conradson carbon	% m/m	≤ 0.2	
Ash content	% m/m	≤ 0.01	
Lubricity	µm	≤ 400	

1) Different values for cold temperature test fuel: RVP: 56-95 KPa.
2) Ethanol meeting EN 15376 is the only oxygenate to be intentionally added.
3) FAME content to meet the specification of EN 14214.
4) Even though oxidation stability is controlled it is likely that shelf life will be limited.

US – CERTIFICATION UNLEADED GASOLINE FUEL

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
Octane	RON	93 min	93 min		
Octane	(R+M)/2			87.5-88.1	91.8-92.8
Sensitivity	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
DVPE (Evap)	PSI	8.0-9.2	7.6-8.0		
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	5.0-15.0
Saturates	% vol	Remainder	Remainder	Remainder	Remainder
Lead	g/L	0.013 max	0.013 max	0.0026 max	0.0026 max
Phosphorus	mg/kg	0.0013 max	0.0013 max	0.0013 max	0.0013 max
Total Sulfur	mg/kg	15-80	15-80	15-80	15-80

Fuel Name	E10	EPA Tier 3	EPA Tier 3	EPA Tier 3	Carb LEV III
Specification		40 CFR 1065.710	40 CFR 1065.710	40 CFR 1065.710	40 CFR 86.113-07
Property	Units	General	Low-Temp	High Altitude	Regular
Octane	(R+M)/2	87.0-88.4	87.0-88.4	87.0 min	87.88.4
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 max
Aromatics	% vol	21.0-25.0	21.0-25.0	21.0-25.0	19.5-22.5
Olefins	% vol	3.4-8.6	3.4-8.6	3.4-8.6	4.0-6.0
Benzene	% vol	0.5-0.7	0.5-0.7	0.5-0.7	0.6-0.8
Lead	g/L	0.0026 max	0.0026 max	0.0026 max	0.0026 max
Phosphorus	mg/kg	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	1000 min	1000 min	1000 min	1000 min

US – CERTIFICATION DIESEL FUEL

Fuel Property	Unit	Federal Specifications		CARB specifications	Test[3]
		1-D[2]	2-D		
Cetane Number (natural)		40-54	40-50	47-55	D-613
Cetane Index		40-54	40-50	–	D-976
Distillation Range	°F (°C)				D-86; 13 CCR section 2282(g)[3]
Initial Boiling Point	°F (°C)	330-390 (166-199)	340-400 (171-204)	340-420 (171-216)	
10% Point	°F (°C)	370-430 (188-221)	400-460 (204-238)	400-490 (204-254)	
50% Point	°F (°C)	410-480 (210-249)	470-540 (243-282)	470-560 (243-293)	
90% Point	°F (°C)	460-520 (238-271)	560-630 (293-332)	550-610 (288-321)	
End Point	°F (°C)	500-560 (260-293)	610-690 (321-366)	580-660 (304-349)	
API gravity		40-44	32-37	33-39	D-287
Total Sulfur	ppm	7-15	7-15	7-15	D-2622; 13 CCR section 2282(g)[3]
Nitrogen Content	ppm			100-500	13 CCR section 2282(g)[3]
Total Aromatic Hydrocarbons	% vol.	8 (min.)[1]	27 (min.)[1]	8-12	D-1319; 13 CCR section 2282(g)[3]
Polycyclic Aromatic Hydrocarbons	% vol.			1.4 (max.)	
Flashpoint (min.)	°F (°C)	120 (48.9)	130 (54.4)	130 (54)	D-93
Viscosity at 40°F (4°C)	mm^2/sec	1.6-2.0	2.0-3.2	2.0-4.1	D-445

1) Remainder shall be paraffins, naphtenes and olefins.
2) Basic Certification fuel is the grade 2-D Diesel. Grade 1-D is allowed only if the engine manufacturer demonstrates that this fuel will be the predominant in-use fuel.
3) ASTM standards and/or California Tile 13, CCR procedures.

Power electronics

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EVAPORATIVE EMISSIONS STANDARDS

CONVENTIONAL US / EU TEST PROCEDURES

Sequence for evaporative emissions testing

Test sequence		US (EPA)	EU (Euro 1, Euro 2)
Preconditioning	Fill to 40% with test fuel	8.7-9.2 RVP EPA II (18 cycles)	8.1-9.3 RVP Purge canister by driving or air purge, 2x diurnal heat build (heat fuel 16-30°C), 1 ECE + 2 EUDC cycles
Soak	12-36 hours	At 68-86°F ambient	At 20-30°C ambient
Fuel drain / fill	Drain tank, fill 40± 2% with test fuel	Fuel 45-60°F	Fuel 10-14°C
Diurnal test (SHED)	Heat fuel tank for 1 hour	60-84°F	From 16-30°C
Exhaust test	Driving cycle	EPA III (emissions measured for TA)	ECE+EUDC cycle (emissions not measured for TA)
Hot soak test	1 hour	At 68-86°F ambient	At 23-32°C ambient
Emissions standard: Diurnal test + hot soak test: 2g			

Regulation 715/2007/EC, Regulation 692/2008/EC Annex VI, UN/ECE Regulation No. 88 Annex 7

Test sequence: Euro 3-4-5, TA 1/2000	
Fuel drain / fill	Fill to 40% with test fuel
Canister preconditioning	Canister loading: Repeated diurnal heat builds or butane/N_2 loading to 2g breakthrough
Fuel drain / fill	Drain tank, fill to 40% with test fuel
Vehicle preconditioning	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 6h at 20±2°C ambient)
Real time diurnal test	1 heat build in 24h in VT SHED, cycle from 20-35°C, ΔT=15K
Emissions standard: Diurnal test + hot soak test: 2g	

New Euro 6c/d emissions regulations are a part of Worldwide harmonized Light vehicles Test Procedure – Global Test Regulation (see next page).

NEW WLTP GLOBAL TEST REGULATION (GTR 19)

Sequence for evaporative emissions testing amended by Europe Commission on 22 June 2017

GTR Test sequence for non sealed fuel tank: Euro 6c/d	
Fuel drain and refill	Fill to 40% with test fuel
Preconditioning drive	Two times Low-Medium-Low phase for Class 1, 23±3°C ambient [1)]
Soak	12-36 hours 23±3°C ambient
Load **Aged** canister	2 g breakthrough Canister after Bench ageing connecting to car
Test drive	Two times Low-Medium-Low phase for Class 1, 23±°C ambient
Hot soak test: **M_{HS}**	60min ±0.5 min at 23-31°C ambient
Soak	6-36 hours (min 6h at 20±2°C ambient)
1st day diurnal: **M_{D1}**	24h in VT SHED, cycle from 20-35-20°C, ΔT=15K
1st day diurnal: **M_{D2}**	24h in VT SHED, cycle from 20-35-20°C, ΔT=15K
Emission calculation	**$M_{HS} + M_{D1} + M_{D2} + 2xPF < 2g/test$**

Emission test is executed on canister after bench ageing

Canister Bench ageing and Tank Permeation Factor	
Canister bench ageing	Temperature conditioning 50 cycles, Canister vibration conditioning 12h, Fuel Ageing 300 cycles
Tank Permeability Factor	Ageing by 20 weeks, 40% fill at 40°C, **$PF = HC_{20w} - HC_{3w}$**

Sequence for evaporative emissions testing proposed by Task Force in development

GTR Test sequence for sealed fuel tank: Euro 6c/d	
Additional requirements under discussion	Load aged canister to 2 g breakthrough then purge up to 85% fuel consumption equivalent. Tank pressure relief opening and puff loss determination by connecting of 2nd canister. Battery charge before Test drive in case of OVC-HEV
Emission calculation	**$M_{HS} + M_{D1} + M_{D2} + 2xPF < 2g/test$**

Alternative option of calculation by Contracting Party: **M HS + M Dmax + PF < limit value determined by CP.**
New Euro 6c/d emissions regulations is a part of Worldwide harmonized Light vehicles Test Procedure (GTR). Introduction of Euro 6 in 1 September 2019 for all new vehicles.

1) 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.

ENHANCED EVAPORATIVE EMISSIONS

US FEDERAL / CALIFORNIA REQUIREMENTS

Temperature	Test sequence	
	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/N2 mix
	Exhaust test: EPA III	Exhaust test: EPA III
EPA: 90-100°F CARB: 100-110°F	1-6h soak **Running loss test:** EPA II, 2x NYCC, EPA II	Not required
	1h hot soak test (EPA 95 / CARB 105°F)	**1h hot soak test** (68-86°F)

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

Temperature	Test sequence	
	3-day diurnal	Supplemental 2-day diurnal
EPA: 90-100°F CARB: 100-110°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 72h EPA cycle 72-96°F, CARB cycle 65-105°F	**Diurnal emission test 2 heat builds in 48h** EPA cycle 72-96°F, CARB cycle 65-105°F
EPA/CARB LEV I	2.0 g/test	2.5 g/test
CARB LEV II	0.5 g/test	0.65 g/test
EPA Tier II	0.95 g/test	1.2 g/test

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.

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 II requirements

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

	EPA Enhanced & Tier II	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: '96-'99: 20/40/90/100% Tier II: '04-'07: 25/50/75/100%	Enhanced: '95-'98: 10/30/50/100% Tier II: '04-'06: 40/80/100%

Further EPA III requirements

Tier III begins 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.

ENHANCED EVAPORATIVE EMISSIONS

CARB LEV III REQUIREMENTS

- Expand the use of existing zero-evap technology to remaining vehicle classes.
- Two options for complying with total hydrocarbon evaporative emissions from MY2015 onwards.

	Vehicle type (lbs GVWR)	Running Loss (g/mile)	3-day diurnal + hot soak and 2-day diurnal + hot soak	
			Whole vehicle (g/test)	Fuel only (g/test)
Option 1	Passenger cars	0.05	0.35	0.0
	LD trucks ≤ 6,000 lbs		0.50	
	LD trucks 6,000 - 8,500 lbs		0.75	
	MD passenger vehicles			
	MD vehicles 8,501 - 14,000 lbs			
	HD vehicles > 14,000 lbs			

	Vehicle type (lbs GVWR)	Running Loss (g/mile)	Highest whole vehicle diurnal + hot soak (g/test)	Canister bleed (g/test)
Option 2	Passenger cars and LD trucks ≤ 6,000 lbs and 0 - 3,750 lbs LVW	0.05	0.3	0.02
	LD trucks ≤ 6,000 lbs and 3,750 - 5,750 lbs LVW		0.4	
	LD trucks 6,000 - 8,500 lbs and MD passenger vehicles		0.5	
	MD vehicles 8,501 - 14,000 lbs and HD vehicles > 14,000 lbs		0.6	0.03

- Implementation schedule: '15-'17: min average of previous 3 models per year PZEVs. '18-'19 60%, '20-'21 80%, '22 100%.
- 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.

EVAPORATIVE EMISSIONS CHINA

PR OF CHINA

- 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.

CHINA VI REQUIREMENTS (proposal)

Timeline for nationwide implementation of light-duty emission standards scheduled on 1 July 2020 (China 6a)

Type IV diurnal emission test procedure based on CARB test procedure.

- WLTC preconditioning drive and driving cycles, Type I: Low-Medium-High-High.
- Preconditioning test requirements for NOVC and OVC.
- Temperature soak and driving at 38±2°C with connected canister.
- Hot Soak test at initial Temperature =38±2°C; (Temperature range 33-41°C).
- SHED Temperature profile 68-95 °F (20-35°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 NIRCO (tank drain and refill with disconnected canister).
- Emission calculation **M D1 (larger of M HC_24 and M HC_48) + M HS.**
- Deterioration Factor (DF) defined for diurnal emission 0.06 g/day.

CHINA VI Type IV Diurnal emission incl. Hot soak and DF

Stage	Evaporative Limit (proposal) 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

INDIA

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

BRAZIL

Evaporative requirement Proconve-L6 (Current)

Evaporative requirement (E22/E61/E100) = 1.5 g/test during 2 hours SHED;

Evaporative requirement Proconve-L7 (Jan 1, 2022)

1.Evaporative requirement (E22/E61/E100) <= 0,5 g/test during 48 hours SHED;
2.Onboard Refueling Vapor Recovery requirement (ORVR) <= 50 mg/l refueling;

More stringent legislation based on CFR86 (US Federal Regulations, volume 40, part 86).

ON-BOARD REFUELLING VAPOR RECOVERY

- Applicable in all US Federal States. CARB adopted EPA regulation phase-in with 40/80/100% over 3 years.
  Passenger cars MY '98-'00.
  LDT ≤ 6,000 lbs GVW MY '01-'03.
  LDT > 6,000 lbs GVW MY '04-'06.
  Small volume manufacturers for passenger cars have to comply for 100% in MY '00.
- No changes to ORVR procedures for CARB LEV II and EPA Tier II.
- 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 '15 onwards.
- If using California certification fuel, the fuel shall be dispensed at a temperature of 79±1.5°F (26.1±0.8°C) and at a dispensing rate of 9.8±0.3 gal/min (37±1.1 l/min).

Vehicle precon-ditioning	• Fuel drain and fill to 40%. • 6 h min soak at 68-86°F (20-30°C). • 1x EPA II preconditioning drive.
Canister precon-ditioning	• Fuel drain and fill to 40%. • 12-36 h soak. • Load canister with HC vapors until 2g breakthrough at 40 g/h 50% butane/N_2. • Exhaust test: EPA III (recording emissions). • 0-1 h soak at 68-86°F (20-30°C). • Canister purge drive at 68-86°F: EPA II, 2x NYCC, EPA II.
Refueling event	• Disconnect canister(s). • Fuel drain and fill to 10%. • 6-24h soak at 80±3°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 ≥ 85%. Administrator may use 4 gal/min rate (15 l/min). Dispense fuel temperature: 67±1.5°F (19°C).
HC standard: 0.2 g/gallon (0.053 g/l).	

ON-BOARD REFUELLING VAPOR RECOVERY

EPA FUEL DISPENSING SPITBACK TEST

- Applicable in all US Federal States for vehicles ≤ 14,000 lbs GVW. Spitback phase-in same as enhanced EVAP (100% by '99).
- Measurement of liquid fuel spitback from the fuel filler inlet during a refueling event. Stand-alone test in addition to enhanced EVAP tests. If ORVR compliant, manufacturer can request spitback test waiver.
- Fuel used: US Federal certification fuel: 8.7-9.2 RVP.
- Spitback standard: 1.0 g/test.

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

- Canister should be loaded using fuel-tank-refill method described under "Refueling event" section and purged while performing vehicle driving, using either chassis dynamometer procedure or the test track procedure, as described in subparagraphs (d) (1) and (d) (2) of 40CFR 86.153-98.
- Vehicle drivedown shall consume 85% or less of the nominal fuel tank capacity.

China V/VI Type VII ORVR (Proposal)

- Type VII test ORVR emissions requirement < 0.05 g/l based on CARB test procedure.
- Deterioration Factor (DF) defined for ORVR emission 0.01 g/day.
- Test procedure for NIRCO (tank 95% fill and tank drain and refill 10% refill with disconnected canister).

Viper power switch

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ELECTRIFICATION

CALIFORNIA ZERO EMISSION VEHICLE (ZEV) PROGRAM

Electrified vehicles are mandated for certain states in the US through the California Zero Emission Vehicle (ZEV) program. Through section 177 of the federal Clean Air Act the California ZEV program applies for California, and 9 additional states: Connecticut, Maine, Maryland, Massachusetts, New York, New Jersey, Oregon, Rhode Island, and Vermont. NOTE: EPA issued a rule effective November, 2019 withdrawing California's ability to implement it's ZEV program. That lawsuit is still ongoing at the time of publication of this booklet. The ZEV program uses a credit based system. Each vehicle manufacturer obtains ZEV credits based on annual sales of zero emission vehicles (ZEV) and transitional zero emission vehicles (TZEV). ZEVs comprise electric vehicles (EV), fuel cell electric vehicles (FCEVs), range extended battery electric vehicles (BEVx), and neighborhood electric vehicles (NEVs). TZEVs comprise PHEVs and hydrogen internal combustion engine vehicles (HICE).

The ZEV requirement for large volume manufacturers (LVM), having average vehicles sales in California > 20,000 per year is defined in the following table:

Year	2018	2019	2020	2021	2022	2023	2024	2025+
ZEV (EV and FCEV), BEVx, NEV	2%	4%	6%	8%	10%	12%	14%	16%
TZEV PHEV and HICE	2.5%	3%	3.5%	4%	4.5%	5%	5.5%	6%
ZEV Requirement Total	4.5%	7%	9.5%	12%	14.5%	17%	19.5%	22%

Note that the Total ZEV percent requirement can be fulfilled by a combination of ZEVs and TZEVs, subject to a minimum number of ZEVs that must be sold (Minimum ZEV floor). Additionally, BEVx vehicles are limited to fulfilling a maximum 50% of the requirement that must be met with ZEV credits.

Intermediate Vehicle Manufacturers with 5000 < CA annual vehicle sales ≤ 20,000 are subject to the same total ZEV percent requirement, but there is no minimum ZEV floor (i.e. there is no limit to the number of TZEVs that can be used to fulfill the Total ZEV percent requirement. Small Vehicle Manufacturers with CA annual vehicle sales ≤ 5,000 are exempt from ZEV mandate. ZEV credits to be applied to the ZEV requirement vary for the different ZEV and TZEV vehicles according to the following tables.

EV and FCEV ZEV credits/vehicle

All Electric Range (AER)	ZEV Credits
AER < 50 Miles	0
50 mi ≤ AER ≤ 350 mi	0.5+.01*AER
350 miles < AER	4

TZEV: PHEV ZEV credits/vehicle

All Electric Range (AER)	ZEV Credits
AER < 10 Miles	0
10 mi ≤ AER ≤ 80 mi	0.3+.01*AER
80 miles < AER	1.1

Note: ZEV credit increased by 0.2 for TZEV vehicles with AER ≥ 10 miles over US06 test cycle.

BEVx ZEV credits/vehicle

All Electric Range (AER)	ZEV Credits
AER < 75 Miles	0
75 mi ≤ AER ≤ 350 mi	0.5+.01*AER
350 miles < AER	4

Note: For BEVx if AER < Gasoline range, credit = 0

TZEV: HICE ZEV credits/vehicle

All Electric Range (AER)	ZEV Credits
AER < 10 Miles	0.75
10 mi ≤ AER ≤ 20 mi	1.05+.01*AER
20 miles < AER	1.25

Note: Requires total vehicle range of 250 miles to qualify as TZEV:HICE.

CALIFORNIA ZERO EMISSION VEHICLE (ZEV) PROGRAM

NEV ZEV credits/vehicle

NEV performance Requirements	ZEV Credits
Constant speed range ≥ 25 Miles Top Speed ≥ 20 mph 0-20 MPH ≤ 6 Sec	0.15

For determination of whether a manufacturer meets its Total Percent ZEV requirement, each ZEV or TZEV sold is multiplied by the ZEV credit value for that vehicle. Thus, for example, an EV with an AER = 375 miles over the UDDS receives the maximum ZEV credit and counts as 4 vehicles when calculating the percent ZEVs. Similarly, a PHEV with 100 mile AER over the UDDS and 25 miles over the US06 cycle receives the maximum PHEV credit and counts as 1.3 vehicles when calculating the percent TZEVs and the total percent ZEVs.

Additional compliance information is available from the California Air Resources Board Zero Emission Vehicle program website.

https://ww2.arb.ca.gov/our-work/programs/zero-emission-vehicle-program

EUROPEAN UNION ZERO AND LOW EMISSION VEHICLE (ZLEV) PROGRAM

There is no electrified vehicle mandate for the European Union, however electrified vehicles are eligible for super-credits and an increased ZLEV factor, up to 5%, is applied to CO_2 requirements for ZLEV credits exceeding 15% of vehicle sales in 2025 and 35% in 2030.

See European Union section on CO2 for details on ZLEV factor adjustment.

ZLEV credits can be earned for vehicles emitting less than 50 g/km of CO_2 on the WLPT. The following table presents the ZLEV credit vs. CO_2 emission level.

EV, FCEV and PHEV ZLEV credits per vehicle

CO_2 Emissions (g/km)	ZLEV Credits
CO_2 = 0 g/km (EV)	1
0 g/km < CO_2 < 50 g/km	1 - .014 * CO_2 g/km
CO_2 ≥ 50 g/km	0

Certain countries qualify as Low ZLEV member states resulting in a 1.85 multiplier on the ZLEV credit. The following 14 member states meet the criteria in 2017: Bulgaria, Cyprus, Czech Republic, Estonia, Greece, Croatia, Ireland, Lithuania, Malta, Poland, Romania, Slovenia, Slovakia.

PR OF CHINA NEW ENERGY VEHICLE (NEV) PROGRAM

The China New Energy Vehicle (NEV) program (revised 2019) requires that credits be produced equivalent to a weighted percent of sales.

NEV credits can be earned for:

- Plug in Hybrid Electric Vehicles (PHEV) – up to 1.6 per vehicle.
- Battery Electric Vehicles (BEV) – 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) – up to 5 per vehicle.

Model Year	Weighted % of sales
2019	10 %
2020	12 %
2021	14 %
2022	16 %
2023	18 %
2024+	TBD

PHEV

NEV credits are based on All Electric Range (AER), curb mass, consumption fuel consumption in charge sustaining mode and electric energy consumption in charge depleting mode

Fuel Consumption ≥ 70% of phase 4 FC Target: 0.8 NEV credit per vehicle

Fuel Consumption < 70% of phase 4 FC Target: 1.6 NEV credits per vehicle

(See PR of China section on CO_2/FE for phase 4 fuel consumption targets)

The NEV credits determined are are reduced by 50% if the vehicle's Electric Energy Consumption (EEC) in charge depleting mode is greater than 135% of the Electric Energy Consumption target (Et) for a BEV of the same mass. See the BEV section on the next page for the table defining E_t

PR OF CHINA NEW ENERGY VEHICLE (NEV) PROGRAM

BEV

NEV credit for a vehicle is based on AER, curb mass, and Electric Energy Consumption (EEC) of the vehicle compared to the Electric Energy Consumption target (Et) for the vehicle based on vehicle mass.

NEV Credits per vehicle = $R_f * E_f$

BEV Electric Energy Factor (E_f)

$(E_t/EEC) < 1$	$E_f = 0.5$
$1 < (E_t/EEC) \leq 1.5$	$E_f = (E_t/EEC)$
$1.5 < (E_t/EEC)$	$E_f = 1.5$

Electric Energy Consumption threshold (E_t)

Curb Mass (kg)	(E_t) kWh/100km
Mass ≤ 1000 kg	0.4 + 0.0112*M
1000 kg < Mass ≤ 1600 kg	3.81 + 0.0078*M
1600 kg < Mass	10.28 + 0.0038*M

Range Factor (R_f) versus AER

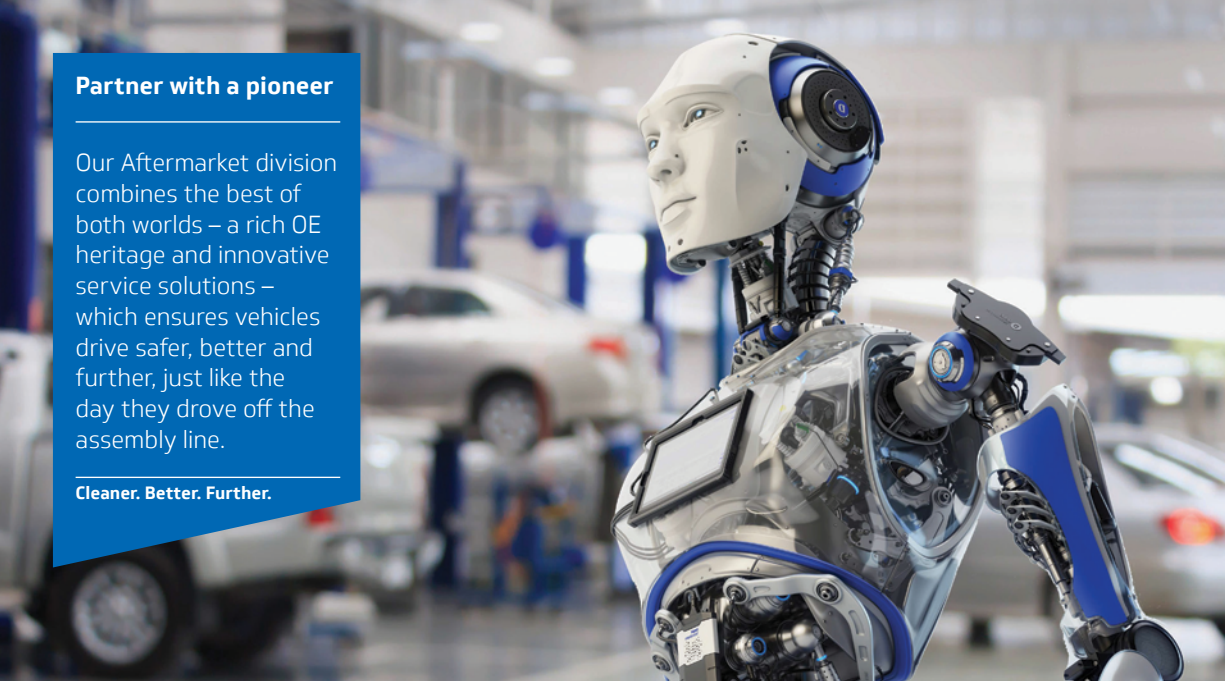
All Electric Range (AER)	R_f
AER < 100 km	0
100 km ≤ AER ≤ 150 km	1
150 km ≤ AER ≤ 500 km	0.4+0.006*AER (km)
500 km < AER	3.4

FCEV

NEV credit based on AER, fuel cell power, electric motor power
- AER < 300 km - 0 NEV credits per vehicle
- Fuel Cell Power < 30% of Motor Power or 10 kw:
  - NEV credit per vehicle = 0.5*(0.08*FC power [kw])
- Fuel Cell Power ≥ 30% of Motor Power and 10 kw:
  - NEV credit per vehicle = 2*(0.08*FC power [kw])

The maximum NEV credit for a fuel cell vehicle cannot exceed 6

For determination of whether a manufacturer meets its total percent NEV requirement, each BEV, PHEV or FCEV sold is multiplied by the NEV credit value for that vehicle. Thus, for example, a BEV with an AER = 500 km with an Electrical Energy Consumption (EEC) equal to E_t receives 3.4 ZEV credits and counts as 3.4 vehicles when calculating the percent NEVs. Similarly, a PHEV with an EEC = Et and Fuel Consumption < 70% of phase 4 FC Target receives 1.6 NEV credits and counts as 1.6 vehicles when calculating the total percent NEVs.



Partner with a pioneer

Our Aftermarket division combines the best of both worlds – a rich OE heritage and innovative service solutions – which ensures vehicles drive safer, better and further, just like the day they drove off the assembly line.

Cleaner. Better. Further.

MOTORCYCLE EMISSIONS STANDARDS

EUROPEAN UNION

Environmental requirements L-category vehicles[1] Framework Dir. 2002/24/EC[2] and Dir. 97/24/EC[3] (was repealed on 31 Dec 15); Vehicle classification (Cat. L1e to L7e): Article 1 of Framework Dir. 2002/24/EC. As transitional provision for Cat. L1e, L2e and L6e (two- and three-wheeled mopeds and light quadricycles) Dir. 2002/24/EC, 97/24/EC and 2013/60/EU will remain applicable until 31 Dec 17.

Test type I limits, tailpipe emissions after cold start

EURO 2 AND EURO 3 STEP									
Vehicle Category	Vehicle Category Name	Classification (cm^3)	Euro Level	Emissions (mg/km)				Test cycle	Applicable as of
				CO	HC	NOx	HC+NOx		
L1e[4]	Two-wheel moped	< 50	2+3	1,000	–	–	1,200	ECE R47	2000
L3e	Two-wheel motorcycle	< 150	2	5,500	1,200	300	–	ECE R40, UDC	2003
		≥ 150	2	5,500	1,000	300	–	ECE R40, UDC	2003
		< 150	3	2,000	800	150	–	ECE R40, UDC[5]	2006
		≥ 150	3	2,000	300	150	–	ECE R40, UDC+EUDC[6]	2006
		v_{max} < 130 km/h	3	2,620	750	170	–	GTR No 2	2006
		v_{max} ≥ 130 km/h	3	2,620	330	220	–	GTR No 2	2006

1) L-category is the family name of light vehicles such as powered cycles (cat. L1e-A), two- and three-wheeled mopeds (cat. L1e-B, resp. L2e), motorcycles without and with side car (cat. L3e, resp. L4e), tricycles (cat. L5e) and quadricycles (cat. L6e and L7e).
2) OJ L 124, 9.5.2002, p.1.
3) OJ L 226, 18.8.1997, p.1.
4) Euro 2: sampling start t = 448 s after cold start. Euro 3 since 28 Nov 2013, Euro 2 emission limits apply, sampling start t = 0, weighting 30% cold / 70% warm.
5) Emissions measured for all six modes — sampling start at t = 0.
6) Emissions measured from all modes — sampling start at t = 0.

Vehicle Categ–ory	Vehicle Category Name	Classification (cm^3)	Euro Level	Mass of (mg/km)				Test cycle	Applicable as of
				CO	HC	NOx	HC+NOx		
Positive ignition									
L2e[1)]	Three-wheel mopeds	< 50	2+3	7,000	1,500	400	–	L2+L6: ECE R47 L5+L7 UDC	2003
L5e	Tricycles	≥ 50	2						
L6e[1)]	Light quadricycles	< 50	2-3						
L7e	Heavy quadricyles	≥ 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 quadricyles	≥ 50	2						

1) Euro 3 since 28 Nov 13, Euro 2 emission limits apply, sampling start t=0, weighting 30% cold/70% warm.

EUROPEAN UNION

Revised type-approval package Euro 4 and Euro 5 steps: Reg. (EU) No 168/2013[1] and Reg. (EU) No 134/2014[2] first applicable on a mandatory basis as of 01 Jan 16[3]. Vehicle classification criteria for Cat. L1e to L7e: Article 4 and Annex I of Reg. (EU) No 168/2013. L-category vehicles may be type-approved only if they comply with the following environmental requirements set out in the Annexes to Reg. (EU) No 168/2013.

Test Type	Description	Requirements: Limit values	
		Euro 4 step[4]	Euro 5 step[5]
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 – CI or Hybrid with CI engine: free acceleration test	Recasted Directive 2009/40/EC[6]	
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	Not applicable	
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[7]	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

Euro 5 proposal shall be presented to the Council and European Parliament during 2017, elements: confirmation Euro 5 step, in-use conformity testing requirements, off-cycle emission requirements, particulate number emission limit for certain (sub-)categories, planned to be applied from 2020/2021.

EUROPEAN UNION

TEST TYPE I LIMITS, TAILPIPE EMISSIONS AFTER COLD START (EURO 4 AND EURO 5 STEPS), AND APPLICABLE TEST TYPE

EURO 4 STEP							
Vehicle Category	Vehicle Category Name	Propulsion Class	Mass of (mg/km)				Test cycle
			CO	HC	NOx	PM	
			L_1	L_2	L_3	L_4	
L1e-A	Powered cycle	PI/CI/Hybrid	560	100	70	–	ECE R47
L1e-B	Two-wheel moped	PI/CI/Hybrid	1,000	630	170	–	ECE R47
L2e	Three-wheel moped	PI/CI/Hybrid	1,900	730	170	–	ECE R47
L3e[1)] L4e	Two-wheel motorcycles with and without side-car	PI/CI/Hybrid v_{max} < 130 km/h	1,140	380	70	–	WMTC, Stage 2
L5e-A L7e-A	Tricycle Heavy on-road quad	PI/CI/Hybrid v_{max} ≥ 130 km/h	1,140	170	90	–	WMTC, Stage 2
		CI/CI/Hybrid	1,000	100	300	80	WMTC, Stage 2
L5e-B	Commercial tricycle	PI/PI/Hybrid	2,000	550	250	–	ECE R40
		CI/CI/Hybrid	1,000	100	550	80	ECE R40

1) OJ L60, 2.3.2013, p.52.
2) OJ L53, 21.2.2014, p.1.
3) May be applied on voluntary basis as of 11 Sep 14. Application timing for new types and existing types is set out in detail in Annex IV to Reg. (EU) No 168/2013.
4) Euro 4 step mandatory 01 Jan 16 (new types) / 01 Jan 17 (existing types).
5) Euro 5 step mandatory 01 Jan 20 (new types) 01 Jan 21 (existing types) in accordance with Article 23(4) and (5) of Regulation (EU) No 168/2013.
6) OJ L141, 6.6.2009, p. 12 as amended by Dir. 2010/48/EU.
7) Functional OBD requirements for effective and efficient vehicle repair are set out in Annex XII of Reg. (EU) No 44/2014 (OJ L25, 28.1.2014, p.1).

EURO 4 STEP								
Vehicle Category	Vehicle Category Name	Propulsion Class	Mass of (mg/km)					Test cycle
			CO	THC	NOx	PM		
			L_1	L_2	L_3	L_4		
L6e-A	Light on-road quad	PI/PI/Hybrid	1,900	730	170	–		ECE R47
L6e-B	Light quadrimobile	CI/CI/Hybrid	1,000	100	550	80		ECE R47
L7e-B	Heavy all terrain quad	PI/PI/Hybrid	2,000	550	250	–		ECE R40
L7e-C	Heavy quadrimobile	CI/CI/Hybrid	1,000	100	550	80		ECE R40

EURO 5 STEP								
Vehicle Category	Vehicle Category Name	Propulsion Class	Mass of (mg/km)					Test cycle
			CO	THC	NHMC	NOx	PM[2)]	
			L_1	L_{2A}	L_{2B}	L_3	L_4	
L1e-A	Powered cycle	PI/CI/Hybrid	500	100	68	60	4.5	Revised WMTC[3)]
L1e-B-L7e	All other L-category vehicles	PI/CI/Hybrid	1,000	100	68	60	4.5	Revised WMTC
		CI/CI/Hybrid	500	100	68	90	4.5	Revised WMTC

1) With regards to test type I, the relevant emission limit for L3e-AxE (Enduro, x = 1, 2 or 3) and L3e-AxT (Trial, x = 1, 2 or 3) motorcycles shall be the sum of L 2 (THC) and L 3 (NOx) of Annex VI (A). The emission test results (NOx+THC) shall be smaller than or equal to this limit (L 2 + L 3).

2) PM limits only for vehicles equipped with CI or GDI engines.

3) WMTC Stage 2 and revised WMTC are set out in Appendix 6 of Annex II to Regulation (EU) No 134/2014, pending on Euro 5 proposal.

EUROPEAN UNION

TEST TYPE IV, EVAPORATIVE EMISSIONS

EURO 4 STEP[1]				
Veh. Cat.	**Vehicle Category Name**	**Prop. Class**	**Mass of THC (mg/test)**	**Test Cycle**
L3e L4e	Two-wheel motorcycle with and without side car	PI	2,000	SHED[2]
L5e-A	Tricycle			
L6e-A	Light on-road quad			
L7e-A	Heavy on-road quad			

EURO 5 STEP					
Veh. Cat.[3]	**Vehicle Category Name**	**Prop. Class**	**Permeation Test[4]**		**Mass of THC in SHED Test**
			Fuel Tank	**Fuel Tubing**	**Vehicle**
			(mg/m²/day)		**(mg/test)**
L1e-A	Powered cycle	PI	1,500	15,000	1,500
L1e-B	Two-wheel moped		1,500	15,000	1,500
L2e	Three-wheel moped		1,500	15,000	1,500
L3e L4e	Two-wheel motorcycle with and without side-car				1,500
L5e-A	Tricycle				1,500
L5e-B	Commercial tricycle		1,500	15,000	1,500
L6e-A	Light on-road quad				1,500
L6e-B	Light quadrimobile		1,500	15,000	1,500
L7e-A	Heavy on-road quad				1,500
L7e-B	All terrain quad		1,500	15,000	1,500
L7e-C	Heavy quadrimobile		1,500	15,000	1,500

1) 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.
2) 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.
3) For (sub-)Cat.L1e, L2e, L5e-B, L6e-B, L7e-B and L7e-C, applicable test type to be determined pending the Euro 5 proposal. The vehicles subcategory will either be made subject to permeation testing or SHED testing, the respective other test type shall not apply.
4) Permeation test procedure set out in appendix 2 to Annex V of Reg. (EU) No 134.2014.

EUROPEAN UNION

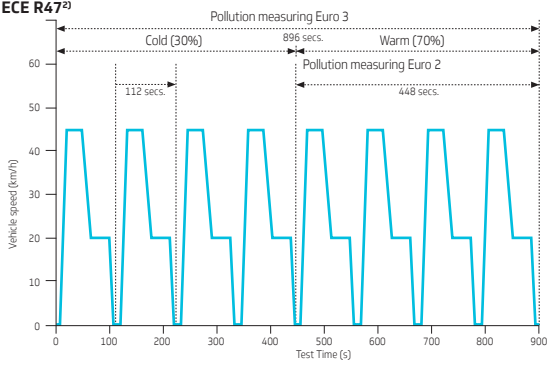
TEST TYPE V, POLLUTION OF EMISSION CONTROL DEVICES, MINIMUM DISTANCE ACCUMULATION [1]

Veh. Cat. (x=1, 2 or 3)	Vehicle Category Name	Euro 4 Durability Mileage & Euro 5 Steps, Full Durability Distance (km)
L1e-A	Powered cycle	5,500
L3e-Axt	Two-wheel trial motorcycle	
L1e-B	Two-wheel moped	11,000
L2e	Three-wheel moped	
L3e-AxE	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 quadri-mobile	
L7e-C	Heavy quadri-mobile	
L3e L4e L7e-A	Two-wheel motorcycle with and without side-car (v_{max} ≥ 130 km/h)	35,000

1) 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.

WMTC

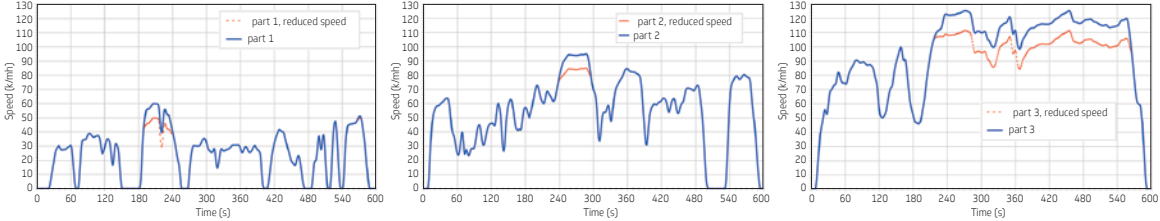
ECE R47 [2]



2) ECE R47 test cycle set out in Dir. 2013/60/EU and 97/24/EC (until 31 Dec 17) and set out in Reg. (EU) No 134/2014 (voluntary after 11 Sep 14, obligatory after 01 Jan 18). NB the EU has not acceded to UN Reg. No 47 and which is therefore not accepted for whole vehicle type-approval of mopeds. Pending the Euro 5 proposal Cat. L1e, L2e and L6e shall be subject to the WMTC as of the Euro 5 step.

WMTC

WORLD HARMONIZED MOTORCYCLE TEST CYCLE – DRIVING CYCLE (UN-ECE GTR No. 02)



Class	1	engine capacity < 150 cm^3 and v_{max} < 100 km/h
Sub-Class	2-1	engine capacity < 150 cm^3 and 100 km/h ≤ v_{max} < 115 km/h or engine capacity ≥ 150 cm^3 and v_{max} < 115 km
	2-2	115 km/h ≤ v_{max} < 130 km/h
	3-1	130 km/h ≤ v_{max} < 140 km/h
	3-2	v_{max} ≥ 140 km/h or engine capacity > 150 cm^3

US FEDERAL / CALIFORNIA

US FEDERAL MOTORCYCLE LIMITS (CFR 40 Part. 86.401)

1980 and later vehicles: 5.0 g/km HC; 12 g/km CO on FTP-75 test.
No crankcase emissions allowed. No evaporative emission regulations for MY 2005 and prior. EPA has adopted new regulations in line with CARB regulations with implementation delayed by 2 years.

EPA Motorcycle Standards (g/km)

Year	Class	Disp. (cc)	HC corp. ave	CO	HC+NOx	
					corp. ave	max
2006+	I	50-169	1.0	12		
	II	170-279	1.0	12		
2006-09	III	≥ 280	1.0	12	1.4	5.0
2010+	III	≥ 280		12	0.8	5.0

Regulations are fuel neutral.
Class I: 0 to 169cc Class II: 170 to 279cc Class III: ≥280cc
Banking and early introduction credits available.
Three wheel vehicles included if they meet the On-Highway Motorcycle criteria.
Mopeds and scooters covered under Non-Road Recreational standards.

CALIFORNIA MOTORCYCLE LIMITS

EPA Motorcycle Standards (g/km)

Year	Class	Disp.	HC		CO	HC+NOx	
			corp. ave	max		corp. ave	max
1988-2003	I & II	50-279	1.0	2.5	12		
	IIIa	280-699	1.0	2.5	12		
	IIIb	≥ 700	1.4	2.5	12		
2004-2007	III	≥ 280			12	1.4	2.5
2008+	III	≥ 280			12	0.8	2.5

CHINA AND OTHER AREAS OF THE WORLD

Brazil

Phase-in: PROMOT 4 / WMTC cycle – Idle HC & CO – 2014: 400 ppm of HC revised, and 2% of CO revised – Fixed DR from Jan 2014.
Annual prod: < 10,000 units – CO, HC, NOx 20% > 10,000 units – Mopeds – DF based on 10,000 km.
Motorcycles < 130 km/h – DF based on 18,000 km > 130 km/h – DF based on 30,000 km. (g/km)

Application Date	Category	Displacement	HC	NOx	HC+NOx	CO
Jan 2014	Mopeds (new models)	< 50 cc		0.8	1.0	0.15
	Motorcycles and similar (new models)	< 130 km/h	0.8	2.0	0.15	0.15
		> 130 km/h		0.3	2.0	

Chile

2012: LA-4 - Tier 2, ECE40+EUDC - Euro 3, WMTC - Euro 3

China

Stage	Standard	Implementation Date	
		Type Approval	All sales & registrations
Stage I	GB 14622-2002 (MCs) GB 18176-2002 (mopeds)	Jan 2003	Jul 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)	Jul 2008	Jul 2009 [1]
Stage IV	GB 14622-2016 (MCs) GB 18176-2016 (mopeds)	Jul 2018	Jul 2019

1) This is the original implementation date; actual implementation date extended by 1 year.

	Application Date	Description	Engine Size	HC (g/km)	NOx (g/km)	HC+NOx (g/km)	CO (g/km)	Driving Cycle	Cold Start	Durability
China Stage III (contd.)	2008	2W with Four-Stroke Engine	< 50 CC (moped)	–	–	1.2	1	ECE R47	Yes	10,000 km
			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

	Application Date	Vehicle Type	Vehicle Class	Engine Size V (cc)	Top Vehicle Speed v_{max} (km/h)	Emission Limits (mg/km)					Driving Cycle	OBD requirement	Durability (km)
						HC	NOx	CO	HC+NOx	PM			
China Stage IV	2018	2 Wheels	mopeds	≤ 50	v_{max} ≤ 50	630	170	1,000	–	–	ECE R47	Stage I	11,000
			I	50 < V < 150	v_{max} ≤ 50	380	70	1,140	–	–	WMTC I		20,000
				V < 150	50 < v_{max} < 100								
			II	V < 150	100 ≤ v_{max} < 115						WMTC II-1		
				V ≥ 150	v_{max} < 115								
				V ≤ 1,500	115 ≤ v_{max} < 130						WMTC II-2		
			III	V ≤ 1,500	130≤ v_{max} < 140	170	90	1,140	–	–	WMTC III-1		35,000
				V > 1,500 or v_{max} ≥ 140							WMTC III-2		
		3 Wheels	mopeds	≤ 50	v_{max} ≤ 50	730	170	1,900	–	–	ECE R47		11,000
			PI engine	V > 50 or v_{max} > 50		550	250	2,000	–	–	ECE R40		20,000
			CI engine	V> 50 or v_{max} > 50		–	390	740	460	60			

India	**Standard**	**Description**	**Class**	**Definition**	**Test Cycle**
	BS VI	2W vehicle classification and testing requirements	Class 1	50 < D < 150 CC, v_{max} ≤ 50 km/h or D < 150 CC, 50 < v_{max} < 100 km/h	Part 1 reduced speed cold [0.5] + Part 1 reduced speed hot [0.5]
			Class 2-1	D < 150 CC, 100 ≤ v_{max} < 115 km/h or D ≥ 150 CC, v_{max} < 115 km/h	Part 1 reduced speed cold [0.5] + Part 1 reduced speed hot [0.5]
			Class 2-2	115 ≤ v_{max} < 130 km/h	Part 1 cold [0.3] + Part 2 hot [0.7]
			Class 3-1	130 < v_{max} < 140 km/h	Part 1 cold [0.25] + Part 2 hot [0.5] + Part 3 reduced speed [0.25]
			Class 3-2	v_{max} ≥ 140 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.				
Indonesia	Motorcycle emissions legislation is equivalent to Euro 3				

Japan

Current motorcycle emissions standards introduced in Sept 2013. Standards for motorcycles / larger mopeds use WMTC test cycles. Standards for smaller mopeds continue to be based upon ISDO 6460 test cycle. OBD and Evap emissions standards become compulsory.

Application	**Description**		**CO (g/km)**	**THC (g/km)**	**NMHC (g/km)**	**NOx (g/km)**
Prior 2016	Equivalent class 1		2.2	0.45	–	0.16
	Equivalent class 2 & 3		2.62 (3.48)[2]	0.27 (0.36)[2]	–	0.21 (0.28)[2]
1 Oct 2016[1]	Class 1	Between 50 cc and 150 cc & v_{max} < 50 km/h < 150 cc & v_{max} between 50 and 100 km/h	1.14	0.30	–	0.07
	Class 2	< 150 cc & v_{max} between 100 and 130 km/h > 150 cc & v_{max} < 130 km/h	1.14 (1.58)[2]	0.20 (0.24)[2]	–	0.07 (0.10)[2]
	Class 3	v_{max} > 130 km/h (Class 3)	1.14 (1.58)[2]	0.17 (0.21)[2]	–	0.09 (0.14)[2]
Dec, 2020[3] Nov, 2022[3]			1.00 (1.33)[2][4]	0.10 (0.13)[2]	0.068 (0.088)[2]	0.0045 (0.0063)[2]

1) Applies to new types from 1 Oct 2016, all motorcycles from 1 Sep 2017.
2) Average values (max values).
3) Applied for new model from Dec, 2020 and for existing model from Nov, 2022.
4) CO limit in idle is 0.5 (%).
5) PM limit (0.0045(g/km)) is applied to gasoline direct injection engine.

Singapore	Singapore Government's National Environment Agency is responsible for emissions legislation & air quality. Current emissions standards for motorcycles and scooters are equivalent to Euro 3 for 2W and Euro 2 for 3W, as specified in European Directive 97/24/EC.								
South Korea	**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		2.0 is only adapted Vmax ≥ 130km/h
			2W > 50 CC PI & 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	0.1	0.68	0.60	1.5
Thailand	Level 6 standards, equivalent to Euro 3, 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.								

INDIA BS VI

The Emission Standards for Bharat Stage-VI (BS VI) for 2 wheeler vehicle models manufactured on 1st April 2020 as per GSR 889(E) dt. 16th Sept 2016.

Limit Values for 2 wheelers fitted with PI & CI engines : BS VI

	Vehicle	BS VI Emission Norms							
		CO mg/km	HC mg/km	NOx mg/km	NMHC mg/km	PM mg/km	EVAP mg/test	OBD	Durability milage (km) Type V
PI Vehicles	1 & 2-1	1,000	100	60	68	4.5*	1,500	STAGE I & STAGE II ***	20,000
	2-2	1,000	100	60	68	4.5*			
	3-1 & 3-2	1,000	100	60	68	4.5*			35,000
CI Vehicles	All	500	100	90	68	4.5*	–		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**	–	–

Mass Emission Standards (Bharat Stage VI) for 2 wheelers with Spark Ignition engines with cc <= 50 and Vmax<= 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	

* Applicable to gasoline direct injection (DI) engines only.

** 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.

***OBD stage II will be applicable from 1st April 2023.

INDIA BS VI

The On-Board Diagnostic (OBD) systems for emission control

OBD Functions and Associate.

Monitoring Items	OBD Stage I (BS VI)	OBD Stage II (BS VI) 1st April, 2023
Circuit continuity for all emission related power train component (if equipped)	✔	✔
Distance travelled since MIL ON	✔	✔
Electrical disconnection of Electronic evaporative purge control device (if equipped and if active)	✔	✔
Catalytic converter monitoring	✘	✔
EGR system monitoring	✔	✔
Misfire detection	✘	✔
Oxygen sensor deterioration	✘	✔

IUPR for BS VI Vehicles manufactured on or after 1st April 2023 shall be greater than or equal to 0.1 for all monitors M.

On-board (OBD) diagnostics emission thresholds for BS VI Applicable from 1st April, 2023.

Vehicle class	OBD Stage II/Gasoline			
	CO mg/km	NMHC mg/km	NOx mg/km	PM mg/km
1 & 2-1	1,900	250	300	50[1)]
2-2	1,900	250	300	50[1)]
3-1 & 3-2	1,900	250	300	50[1)]
Vehicle class	**OBD Stage II/Gasoline**			
	CO mg/km	**NMHC mg/km**	**NOx mg/km**	**PM mg/km**
All	1,900	320	540	50

1) In case of P.I engines, applicable to vehicles with direct injection engines.

AER	All Electric Range
AMA	Accelerated Mileage Accumulation
ASM	Acceleration Simulation Mode
BEV	Battery Electric Vehicles
BV	Bed Volume
CAFC	Corporate Average Fuel Consumption
CAFE	Corporate Average Fuel Economy (US)
CF	Conformity Factor
CI	Compression Ignition
COP	Conformity of Production
CWF	Carbon Weight Fraction (US)
DF	Deterioration Factor
DI	Direct Injection
EEC	Electric Energy Consumption
EOBD	European Union On-board Diagnostic
EUDC	Extra Urban Driving Cycle
EVAP	Evaporative Emissions
FAME	Fatty Acid Methyl Esters
FC	Fuel Consumption (EU)
FCEV	Fuel Cell Electric Vehicle
FE	Fuel Economy (US)
FR	First Registration, entry into service
FTP	Federal Test Procedure
GDI	Gasoline Direct Injection
GHG	Greenhouse Gas
GVM	Gross Vehicle Mass
GVW	Gross Vehicle Weight
GVWR	Gross Vehicle Weight Rating
IDI	Indirect Diesel Injection
IUPR	In-Use Performance Ratio
LBS	Pounds (1 lb = 454 g)
LCV	Light Commercial Vehicle
LDT	Light Duty Trucks
LEV	Low Emission Vehicle
LLDT	Light Light Duty Trucks
LPV	Light Passenger Vehicle
LVW	Loaded Vehicle Weight
MDPV	Medium Duty Passenger Vehicle
MIL	Malfunction Indication Lamp
MTBE	Methyl Tertiary Butyl Ether
NEDC	New European Driving Cycle
NEV	New Energy Vehicle (China)
NHV	Net Heating Value of Fuel (US)
NMHC	Non-Methane Hydrocarbons
NMOG	Non-Methane Organic Gases
NTE	Not To Exceed
NYCC	New York City Cycle
OBD	On-board Diagnostic
ORVR	On-board Refuelling Vapor Recovery
PEMS	Portable Emission Measurement System
PHEV	Plug in Hybrid Electric Vehicle
PI	Positive Ignition
PM/PN	Particulate Mass/Number
RAFs	Reactivity Adjustment Factors
RDE	Real Driving Emissions
RM	Reference Mass
RVP	Reid Vapor Pressure

SEA	Selective Enforcement Audit
SG	Specific Gravity of Fuel (US)
SHED	Sealed House for Evaporation Determination
SFTP	Supplemental Federal Test Procedure
SI	Spark Ignition
SULEV	Super Ultra Low Emissions Vehicle
TA	Type Approval
TF	Transfer Function
UDDS	Urban Dynamometer Driving Schedule
ULEV	Ultra Low Emission Vehicle
VM	Vehicle Makers
VT SHED	Variable Temperature SHED
WC	Working Cycle
WLTC	Worldwide Light duty Test Cycle
WLTP	Worldwide Light duty Test Procedure
ZLEV	Zero and Low Emission Vehicle (EU)

ADMINISTRATIONS & ASSOCIATIONS

ACEA	European Car Manufacturer Association
CARB	California Air Resources Board
ECE	Economic Commission for Europe
EPA	US Environmental Protection Agency
EU	European Union
MVEG	Motor Vehicle Emissions Group, advisory

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Worldwide emissions standards

Passenger cars and light duty vehicles

2020 | 2021

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