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Innovation for the Real World

2016 | 2017

Worldwide Emissions Standards Passenger Cars and Light Duty

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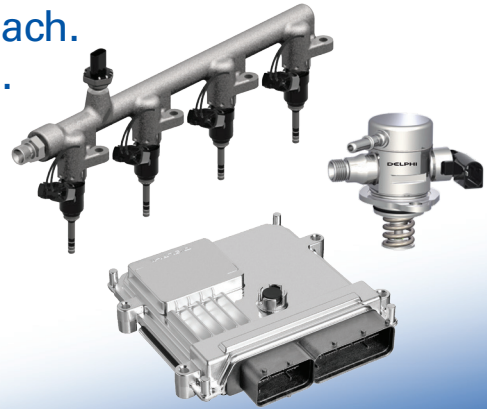
The Delphi Multec® GDi system has a low noise signature and superior resistance to deposits. Its unique non-thermal, laser-drilled flow holes and closed loop control provide high precision spray and flow control. Includes low noise, high pressure pump and controller.



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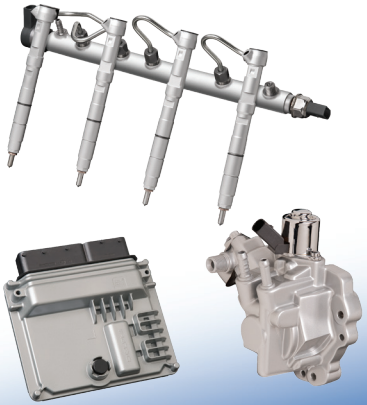
Wonder why our Diesel common rail systems are so popular?

Delphi's light duty Diesel common rail systems offer attractive features to help meet Euro6c and Euro6d emissions standards and beyond. Such as a range of state-of-the-art injectors and a new generation of pumps, driven by powerful controllers with advanced control strategies.



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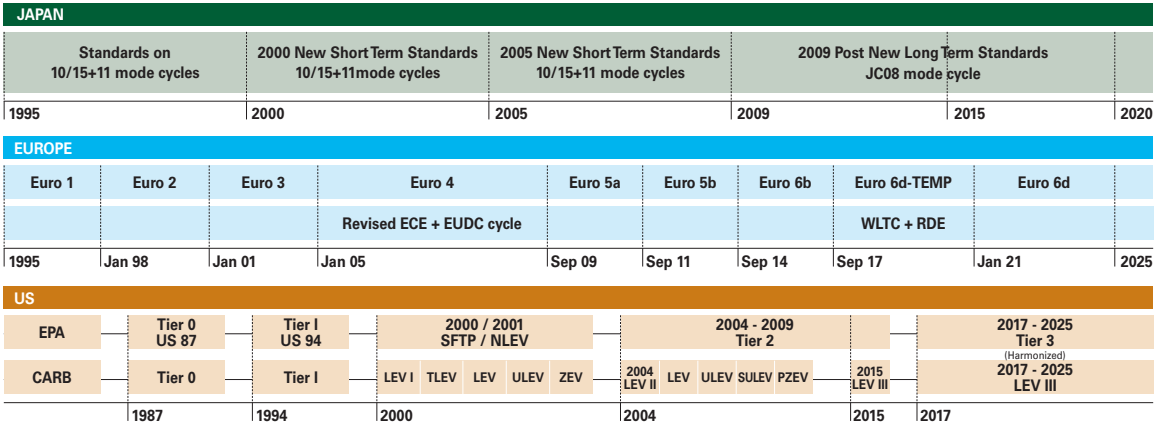
TOXIC EMISSIONS STANDARDS PASSENGER VEHICLES STANDARDS



ECE

ECE regulations are similar to EU directives. 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 is reflecting the Euro 1-6 regulations. A world harmonized procedure / cycle (WLTP; WLTC) is in preparation (see page 13).

EUROPEAN UNION

TYPE APPROVAL

Test	Description	Requirement
Type I	Tailpipe Emissions after a cold start [2]	See pages 5-11 Test cycle: see pages 12-14
Type II	CO Emission test at idling speed	Determination of reference value for I/M [1] & COP
Type III	Emissions of crankcase gases	Standard: zero emission
Type IV	Evaporative Emissions	See page 80
Type V	Durability of anti-pollution devices	See pages 5-11
Type VI	Low temperature test	See pages 5-11
-	OBD	See pages 40-43

[1] I/M: Inspection & Maintenance

[2] RDE Real World Driving Emissions expected to be included in this section after 2017

Note: Type Approval is granted after compliance with tests and requirements

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 Persons	GVW ≤ 3.500 kg [1]	
		M2	Over 9 Persons	GVW ≤ 5.000 kg	
		M3		5.000 kg < GVW	
N	Carriage of Goods Min. 4 wheels	N1 CL 1	N.A.	Max 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		12.000 kg < GVW	

[1] Until Euro 4: Two subgroups: M1 with GVW ≤ 2.500 kg and M1 with 2.500 kg < GVW ≤ 3.500 kg

EUROPEAN UNION

EURO 1-4 - PASSENGER CARS M (≤ 2,5T GVW, ≤ 6 SEATS)

Directive Text Number		Euro 1 (EC 93) [1]		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/EEC, as amended by 98/69/EC and 2003/76/EC			
Application Date	month/year	TA: Jul 1992 FR: Jan 1993		TA: Jan 1996 FR: Jan 1997		TA: Jan 2000 FR: Jan 2001		TA: Jan 2005 FR: Jan 2006	
Test type	-	URBAN (40 sec idle) + EUDC		URBAN (40 sec idle) + EUDC		Rev. Urban (10 sec idle) + EUDC		Rev. Urban (10 sec idle) + EUDC	
Combustion Type		PI	CI	PI	CI [2]	PI	CI	PI	CI [4]
HC	g/km	-	-	-	-	0,20	-	0,10	-
NOx	g/km	-	-	-	-	0,15	0,5	0,08	0,25
HC+NOx	g/km	0,97 (1,13)	0,97 (1,13)	0,50	0,70	-	0,56	-	0,30
CO	g/km	2,72 (3,16)	2,72 (3,16)	2,20	1,00	2,30	0,64	1,00	0,50
PM	mg/km	-	140 (180)	-	80	-	50	-	25
Deteriation 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: 1,0 PM: 1,2	CO, HC, NOx: 1,2	CO: 1,1 HC+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	-	NO	NO	NO	NO	YES	YES	YES	YES

[1] In brackets: COP values [2] Limits for IDI Diesel. For DI Diesel until 30/09/1999: HC+NOx: 0,90 g/km, CO: 1,00 g/km, PM: 100 mg/km

[3] Newly required recording of in-use durability [4] Until 12/2002 Diesel cars with GVW > 2 t and - a) > 6 seats or - b) off road vehicles were considered as N1 vehicles

EUROPEAN UNION

EURO 1-4 - LARGE PASSENGER CARS AND LIGHT DUTY TRUCKS N1 (> 2,5 T GVW, 7-9 SEATS, LDT ≤ 3,5 T)

Directive Text Number		Euro 1 (EC 93) 93/59/EEC			Euro 2 (EC 96) 96/44/EC or 94/12/EC and 93/116/EEC						Euro 3 (EC 2000) 70/220/EEC, as amended by 98/69/EC and 2003/76/EC						Euro 4 (EC 2005) 70/220/EEC, as amended by 98/69/EC and 2003/76/EC					
Vehicle Class		Class 1 ≤ 1250 kg [1]	Class 2 > 1250 kg ≤ 1700 kg [1]	Class 3 > 1700 kg [1]	Class 1 ≤ 1250 kg [1]		Class 2 > 1250 kg ≤ 1700 kg [1]		Class 3 > 1700 kg [1]		Class 1		Class 2		Class 3 [4]		Class 1		Class 2		Class 3 [4]	
Application Date	month /year	TA: Oct 1993 FR: Oct 1994			TA: Jan 1997 FR: Oct 1997		TA: Jan 1998 FR: Oct 1998		TA: Jan 1998 FR: Oct 1999		TA: Jan 2000 FR: Jan 2001		TA: Jan 2001 FR: Jan 2002		TA: Jan 2001 FR: Jan 2002		TA: Jan 2005 FR: Jan 2006		TA: Jan 2006 FR: Jan 2007		TA: Jan 2006 FR: Jan 2007	
Test type	-	URBAN (40 sec idle) + EUDC			URBAN (40 sec idle) + EUDC						Rev. Urban (10 sec idle) + EUDC						Rev. Urban (10 sec idle) + EUDC					
CombustionType		Same limits for SI and CI engines			PI	CI	PI	CI	PI	CI	PI	CI	PI	CI	PI	CI	PI	CI	PI	CI	PI	CI
HC	g/km	-	-		-						0,20	-	0,25	-	0,29	-	0,10	-	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	g/km	0,97 (1,13) [2]	1,4 (1,6) [2]	1,7 (2,0) [2]	0,5	0,7 (0,9) [2]	0,6	1,0 (1,3) [2]	0,7	1,2 (1,6) [2]	-	0,56	-	0,72	-	0,86	-	0,30	-	0,39	-	0,46
CO	g/km	2,72 (3,16) [2]	5,17 (6,0) [2]	6,9 (8,0) [2]	2,20	1,0	4,0	1,25	5,0	1,5	2,30	0,64	4,17	0,8	5,22	0,95	1,0	0,50	1,81	0,63	2,27	0,74
PM	mg/km	140 (180) [2][3]	190 (220) [2][3]	250 (290) [2][3]	-	80 (100) [2]		120 (140) [2]		170 (200) [2]	-	50	-	70	-	100	-	25	-	40	-	60
EOBD	-	NO			NO						YES [5]						YES [5]					

[1] Reference weight in running order plus 25 kg [2] in brackets: COP values [3] Limits Diesel [4] Included Large Passenger cars (> 2,5 t GVW)

[5] TA and FR application dates for EOBD differ from non OBD related dates: See EOBD section for more details

For Euro 2: COP =TA values (if not mentioned otherwise)

EUROPEAN UNION

OTHER 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 & diesel fuels
  (Dir 98/70/EC as amended by 2003/17/EC)

Cat M_1 and N_1 CL I ≤ 2,5 t GVW and/or ≤ 6 seats	CO	15 g/km
New types from 01 Jan 2002	HC	1,8 g/km
Cat N_1 CL II, M_1 > 6 seats, 2,5 t < GVW ≤ 3,5 t	CO	24 g/km
New types from 01 Jan 2003	HC	2,7 g/km
Cat N_1 CL III	CO	30 g/km
New types from 01 Jan 2003	HC	3,2 g/km

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

The benefits of Diesel common rail. Now available for small engines.

The Delphi Unit Pump Common Rail System leverages advanced Diesel common rail technology for small engines. It's a cost-effective, robust solution to help manufacturers achieve optimal efficiency and meet stringent emissions standards.

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EURO 5-6 REGULATION

- 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…)
  - Vehicles with reference mass > 2.000 kg and designed to carry at least 7 occupants

    From 01 Sep 12, no more valid for "true" off-road vehicle
  - 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 III limits for Euro 5.

- Test cycle: NEDC [1] (see page 12)
  - RDE [2] to be introduced as a new and additional certification test to the applicable test cycle with Euro 6c/6d (see page 14)
  - WLTP [3] to be introduced with Euro 6c/6d at the earliest (see page 13)

- New reference fuels (see page 76)

  For Type 1 test: Gasoline E5 E10 Flex fuel E85; Diesel: B5

  For Type 6 test: Gasoline E5 E10 Flex fuel E75

- Unrestricted and standardized access to vehicle repair and maintenance information

- Items to be finalized for Euro 6c/6d
  - RDE
  - Additional pollutants regulations
  - Vehicle weight
  - Auxiliary devices
  - Evaporative emissions
  - Road load determination
  - Battery state of charge

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

[1] NEDC - New European Driving Cycle

[2] RDE - Real Driving Emissions

[3] WLTP - Worldwide Light duty Test Procedure

EUROPEAN UNION

EURO 5-6 SPARK IGNITION EMISSION LIMITS

Emissions	Unit	PC M [1], LDT N1 CL 1				LDT N1 CL 2				LDT N1 CL 3, N2			
		Euro 5a	Euro 5b/b+	Euro 6b	Euro 6c/6d	Euro 5a	Euro 5b/b+	Euro 6b	Euro 6c/6d	Euro 5a	Euro 5b/b+	Euro 6b	Euro 6c/6d
THC	mg/km	100	100	100	100	130	130	130	130	160	160	160	160
NMHC		68	68	68	68	90	90	90	90	108	108	108	108
NOx		60	60	60	60	75	75	75	75	82	82	82	82
CO		1.000	1.000	1.000	1.000	1.810	1.810	1.810	1.810	2.270	2.270	2.270	2.270
PM [2] [3]		5,0	4,5	4,5 [2]	4,5 [2]	5,0	4,5	4,5	4,5	5,0	4,5	4,5	4,5
PN # [3]	Nb/km	-	-	6,0 * E11 [4]	6,0 * E11	-	-	6,0 * E11 [4]	6,0 * E11	-	-	6,0 * E11 [4]	6,0 * E11

[1] No exemption for gasoline Passenger Car [2] Applicable to gasoline DI engines only [3] Test procedure defined in UN Reg 83 Suppl 7

[4] Until 3 years after the dates for type approval / 1st registration particle emission limit of 6,0 x E12 may be applied to Euro 6 spark ignition DI vehicles upon request of manufacturer

EURO 5-6 COMPRESSION IGNITION EMISSION LIMITS

Emissions	Unit	PC M [1], LDT N1 CL 1			LDT N1 CL 2			LDT 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
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 [2]		5,0	4,5	4,5	5,0	5,0	4,5	5,0	5,0	4,5
PN #	Nb/km	-	6,0 * E11	6,0 * E11	-	6,0 * E11	6,0 * E11	-	6,0 * E11	6,0 * E11

[1] Exempted M1 vehicles have to comply with N1CI3 test I emissions limits - No more exemption for passenger cars from Euro 6 [2] Test procedure defined in UN Reg 83 Suppl 7

EUROPEAN UNION

EURO 5-6 IMPLEMENTATION ROADMAP

Vehicle Class		Euro 5b	Euro 6a	Euro 6b	Euro 6c	Euro 6d-Temp	Euro 6d
M, N1 Cl I	New Types	01Sep11		01Sep14		01Sep17	01Jan20
	New Vehicles	01Jan13		01Sep15	01Sep18	01Sep19	01Jan21
N1 Cl II, III, N2	New Types	01Sep11		01Sep15		01Sep18	01Jan21
	New Vehicles	01Jan13		01Sep16	01Sep19	01Sep20	01Jan22

Durability Requirements starting Euro 5: 160.000 km

Assigned Euro 5 DFs: PI: CO: 1,5; THC and NMHC: 1,3; NOx: 1,6; PM: 1,0
CI: CO: 1,5; NOx and THC+NOx: 1,1; PM/PN: 1,0

Alternatives: Calculated DFs based on Standard Road Cycle (SRC)
Test ageing bench: PI based on Standard Bench Cycle (SBC)
CI based on Standard Diesel Bench Cycle (SDBC)

Assigned Euro 6 DFs: PI: no change
CI: TBD

Or certification with aged (or rapid aged) exhaust system mandatory (t.b.c.)

In-Service Conformity

Up to 100.000 km or 5 years

Low Temperature Test (-7°C)

No change on positive igniton vehicles.

Compression ignition: Demonstration at TA of

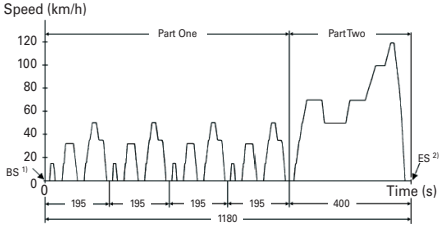
- Performance of NOx aftertreatment device reaching sufficiently high temperature for efficient operation within 400 sec after a cold start (-7°C)
- Operation strategy of the EGR including its functioning at low temperature
- Potential introduction of NOx limitation (Gasoline & Diesel) with Euro 6c (t.b.c.)
- A reduction of HC and CO limits with Euro 6c (t.b.c.)

Evaporative emissions (see page 80)

Note: Euro 6c = Euro 6b + final particle number standards for spark ignition + OBD + use of E10 and B7 reference fuel

EUROPEAN UNION

DRIVING CYCLES: NEDC
URBAN (ECE) + EXTRA-URBAN (EUDC) CYCLE



1) BS - Beginning of Sampling, engine start 2) ES - End of Sampling

	Urban cycle = 820 s
	Urban + extra-urban cycles = 1.220 s (MVEG-A) Revised
Euro 3 onw. ▼	Urban + Extra-urban cycles = 1.180 s (MVEG-B) Revised
	Urban cycle = 780 s (-7°C)

Total duration (ECE+EUDC):	1.180 s
Length:	11.007 km
Average speed:	33,6 km/h
Maximum speed:	120 km/h

Cycle revision for Euro 3 onwards
- Modification of the start-up phase: deletion of the 40 s idle period prior to bag sampling start
- Simultaneous engine crank and bag sampling start 111 s idle after crank

Prior to Euro 3
- Start and 40 s idle period to bag sampling start

! This cycle is intended to be replaced by the WLTC 1) (see page 13).

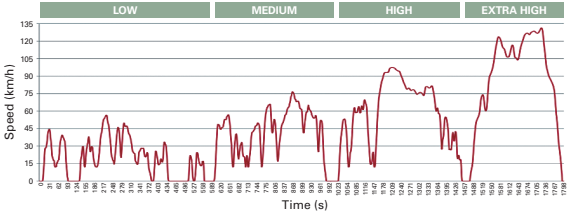
1) WLTC - Worldwide Light duty Test Cycle

WLTP

PROPOSED WLTP

- Scope
  World harmonized way to determine Passenger Car emissions
- Introduction
  Earliest expected application in Europe Sep 2017
- Cycle construction
  - Extra high speed part only for European Union
  - India and Japan require special high and extra high speed part for vehicles with low power/mass ratio
- Test conditions
  Be representative for real world driving conditions. AC on/off, audio system on/off, battery state of charge; ambient temperature during test, vehicle weight are being debated and defined in separate working groups.
- Additional items for worldwide emission regulation harmonization within the framework of WLTP:
  - Additional pollutants 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

WLTC VERSION 5 (PROPOSAL)



	MVEG-B	WLTC
Length (s)	1.180	1.800
Length (km)	11,007	23,26
Idle time (%)	21,8	13
V_{max} (km/h)	120	131,6
$V_{average}$ (km/h)	33,6	46,3
$Accel_{max}$ (m/sec^2)	1	1,6

EUROPEAN UNION

- **RDE** is a new and additional test for M1 vehicle at type approval and throughout its normal life. Certain types of pollutant are checked on public road in real life conditions using PEMS
- It is scheduled to be introduced with Euro 6c/6d limits in Sep 2017 in two steps: Euro 6d-Temp and Euro 6d. There is a monitoring phase that starts in Jan 2016
- The pollutants are
  - NOx and PN
  - CO_2, CO will be recorded. CO can be subject to limit at a later date
- $NTE_{pollutant} = CF_{pollutant} \times TF(p_1,\ldots,p_n) \times$ Euro 6 [1)]
-

CF for NOx	Moderate Conditions	NTE NOx
Euro 6d-Temp	2,1	168 mg/km
Euro 6d	1,0 + 0,5	80 + 40 mg/km

- CF for PN: to be defined in Q3 2016
- Random Cycle generation tool is still considered as a back up in case the PEMS technology is not able to fulfill the PN pollutant measurement requirement; it would generate a random cycle based on EU WLTC drive database for testing in Vehicle Emission Laboratory

CF - Conformity Factor
GVM - Gross Vehicle Mass
NTE - Not To Exceed
PEMS - Portable Emission Measurement Systems
TF - Transfer Function

[1)] Where Euro 6 is the applicable Euro 6 emission limit laid down in Table 2 of Annex I to Regulation (EC) No 715/2007.

Test Trip

- The trip shall be composed of urban (34%), rural (33%) and motorway (33%) roads and last between 90-120 min
- It should be driven by a 'normal' driver. Extreme driving conditions are recognized and sorted.
- Start and end of trip altitude difference shall be less than 100 m.
- Max cumulative positive elevation < 1.200 m / 100 km

Boundary Conditions

- Vehicle test mass shall not exceed 90% pf GVM.
- Temperature: Normal: 0 / +30°C, Extended: -7 / +35°C
- Derogation till Sep 2019: Normal: +3 / +30°C, Extended: -2 / +35°C
- Extended conditions: Apply 60% coefficient
- Altitude: Normal ≤ 700 m, Extended ≤ 1.300 m
- Max speed allowed: 145 km/h (+ tolerance)

Dynamic Conditions

- Included in post treatment tools
- V*a_pos_95 percentile

Note: text is not finalized yet, modifications may still happen

	M1 & N1 cl1		N1 cl2, 3	
	New Type	All Types	New Type	All Types
Euro 6d-Temp	Sep17	Sep19	Sep18	Sep20
Euro 6d	Jan20	Jan21	Jan21	Jan22

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
- 0,07 g/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. Bin 1 corresponds to 0,0 g/mi of all emission categories

LIGHT DUTY VEHICLE - LIGHT DUTY TRUCK - MEDIUM DUTY PASSENGER VEHICLE

g/mi

Standard	Emission Limits (50.000 mi)					Emission 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	0,14	0,100/0,125 [3]	3,4	-	0,015	0,20	0,125/0,156	4,2	0,02	0,018
Bin 9 [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 [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 [2]	0,60	0,195	5,0	-	0,022	0,90	0,28	7,3	0,12	0,032

Notes: Test covered: Federal Test Procedure (FTP), cold carbon monoxide, highway and idle MY > 2004+

[1] 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.

[2] Bins 9-11 expired in 2006 for LD vehicles and LD trucks. And in 2008 for HLD trucks and MD Passenger vehicles.

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

US FEDERAL

TIER 3 STANDARDS

- Tier 3 emission 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).

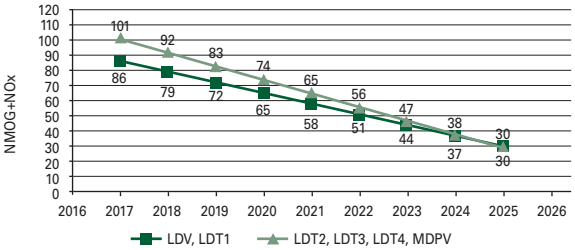
TIER 3 FTP STANDARDS

Tier 3 Certification Bin Standards [FTP, 150.000 mi]				
Bin	NMOG+NOx [mg/mi]	PM [1] [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

[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

Tier III Bin 160 NMOG+NOx =Tier 2 Bin 5 NMOG+NOx
Tier III Bin 30 NMOG+NOx =Tier 2 Bin 2 NMOG+NOx
Tier 3 Federal and LEV III California have been harmonized to created one set of limits for all 50 states.

TIER 3 FLEET AVERAGE NMOG+NOx FTP PHASE-IN [MG/MI]



[1] For LDVs and LDTs over 6.000 IBS GVWR and MDPVs, the fleet average standards apply beginning in MY 2018

US FEDERAL

Cold CO Test

Fleet average requirement for NMHC:

- Provisions for carry forward and carry-back of credits
- Provisions 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 durabililty; NOx Standard: 1,33 x applic. 120.000 vehicle bin
Tier 3: 150 k mi durabililty; NMOG+NOx = 1,0 x applic. 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	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, or 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 3 150 k standards may be met at 120 k km by multiplying the respective standard x 0,85 and rounding to nearest mg/mi FTP limit. Other cycles standards remain the same for either useful life period.

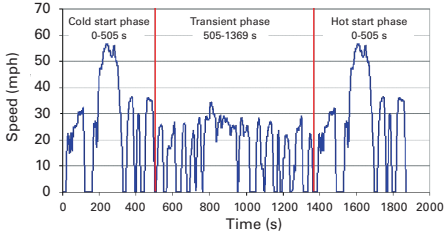
High Altitude: Tier 3 standards allow limited relief at high altitude. Manufacturers may comply with one bin higher at altitude. Bin 70 is capped at 105 mg/mi and Bin 160 gets no relief at altitude.

Enrichment Limits: Enrichment for otto-cycle 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

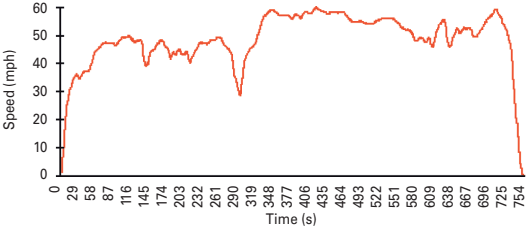
DRIVING CYCLE
CITY CYCLE [1)]



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)

DRIVING CYCLE
HIGHWAY CYCLE [2)]

EPA Highway Fuel Economy Test Driving Schedule
Length 765 s - Distance 10,26 mi - Average Speed 48,3 mph



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)

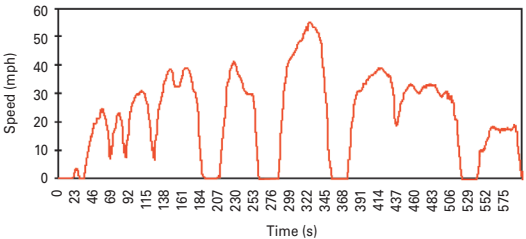
[1)] Also known as: FTP 75, EPA III - Phase I + II also known as: FTP 72, EPA II, UDDS, LA-4
[2)] Also known as Highway Fuel Economy Test - HWFET

US FEDERAL AND CALIFORNIA

DRIVING CYCLE

SC03 AIR CONDITIONING CYCLE

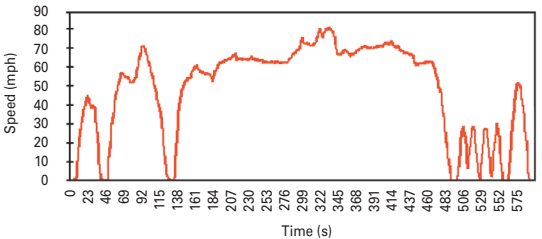
SC03 – Speed Correction Driving Schedule
Duration 598 s - Distance 3,58 mi - Average Speed 21,55 mph



Total duration:	598 s	Max. speed:	54,8 mph (88 km/h)
Length:	3,58 mi (5,76 km)	Initial Idle:	18 s
Average speed:	21,55 mph (34,9 km/h)		

US06 HIGH SPEED/HIGH LOAD CYCLE

US06 or Supplemental FTP Driving Schedule
Duration 596 s - Distance 8,01 mi - Average Speed 48,37 mph



Total duration:	596 s	Max. speed:	80,3 mph (129 km/h)
Length:	8,01 mi (12,86 km)	Initial Idle:	5 s
Average speed:	48,37 mph (77,2 km/h)	Max. acceleration:	8 mph/s

CALIFORNIA

LEV II STANDARDS

Model Passenger Cars or Light Duty Trucks ≤ 8.500 lbs

Durability Vehicle Basis (mi)	Vehicle Emission Category	NMOG (g/mi)	CO (g/mi)	NOx (g/mi)	Formaldehyde (mg/mi)	Particulates (g/mi)
50.000	LEV	0,075	3,4	0,05	15	n/a
	LEV Option 1	0,075	3,4	0,07	15	n/a
	ULEV	0,040	1,7	0,05	8	n/a
120.000	LEV	0,090	4,2	0,07	18	0,01
	LEV Option 1	0,090	4,2	0,10	18	0,01
	ULEV	0,055	2,1	0,07	11	0,01
	SULEV	0,010	1	0,02	4	0,01
150.000 (optional)	LEV	0,090	4,2	0,07	18	0,01
	LEV Option 1	0,090	4,2	0,10	18	0,01
	ULEV	0,055	2,1	0,07	11	0,01
	SULEV	0,010	1	0,02	4	0,01

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

LEV II 50°F/10°C FTP STANDARDS

50°F/10°C emissions 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 were finalized Dec12 and 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 Vehicle Basis (mi)	Vehicle Emission Category [1]	NMOG+ NOx (g/mi)	CO (g/mi)	Formaldehyde (mg/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 thousands of g/mi.

[2] These standards shall apply only to vehicles not included in the phase-in of particulate standards.

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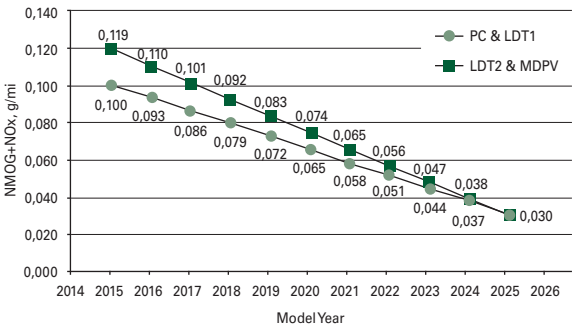
LEV III NMOG+NOx FLEET AVERAGE PHASE-IN



LEV III 50°F/10°C FTP STANDARDS

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

Vehicle 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	0,016
ULEV50	0,100	0,140	0,016
SULEV30	0,060	0,125	0,008
SULEV20	0,040	0,075	0,008

LEV III PARTICULATE PHASE-IN

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

Year	PC, LDT, MDPV	
	PM = 3 mg/mi	PM = 1 mg/mi
2023	100	0
2024	100	0
2025	75	25
2026	50	50
2027	25	75
2028	0	100

CALIFORNIA

SFTP NMOG+NOX AND CO COMPOSITE EXHAUST EMISSION STANDARDS

For the 2015 and subsequent model years, a manufacturer must certify LEV II and LEV III LEVs, ULEVs and SULEVs, such that the manufacturer's sales-weighted fleet-average NMOG+NOx composite emission value, does not exceed the applicable NMOG+NOx composite emission standard. In addition the CO composite emission value of any LEV III test group shall not exceed the CO composite emission standard (see page 21). SFTP compliance shall be demonstrated using the same gaseous or liquid fuel used for FTP certification. In the 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 or 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 2012 and Subsequent Model LEV III Passenger Cars, Light Duty Trucks and Medium Duty Passenger Vehicles

Vehicle Type	Durability Vehicle Basis (mi)	Vehicle 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 Vehicles in these categories are tested at their loaded vehicle weight (curb weight + 300 pounds)	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] Vehicle 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: Manufacturer may certify light duty truck test groups from 6.000 t o 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.

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LEV III SFTP FLEET AVERAGE PHASE-IN

SFTP NMOG+NOx and CO Composite Emission Standards for 2015 and Subsequent 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]										
Vehicles in these categories are tested at their loaded vehicle weight (curb weight + 300 pounds)	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										

[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.

LEV III SFTP PM STANDARDS

SFTP PM Exhaust Emission Standards for 2017 and Subsequent Model LEV III Passenger Cars, Light Duty Trucks and Medium Duty Passenger Vehicles [3]				
Vehicle Type	Test Weight	Mileage for Compliance	Test Cycle	PM (mg/mi)
All PCs; LDTs 0-6.000 lbs GVWR	Loaded vehicle weight	150.000	US06	10
LDTs 6.000-8.500 lbs GVWR; MDPVs				20

[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.

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EMISSION STANDARDS - GASOLINE AND LPG VEHICLES

		Test Mode	Unit	CO	NMHC [1]	NOx	PM [2]	Year
New Short Term	Passenger Car	10-15 Mode	g/km	0,67	0,08	0,08	-	2000
		11 Mode	g/test	19,0	2,20	1,40	-	
	Mini Commercial Vehicle	10-15 Mode	g/km	3,30	0,13	0,13	-	2002
		11 Mode	g/test	38,0	3,50	2,20	-	
	Light Commercial Vehicle (GVW ≥ 1,7 t)	10-15 Mode	g/km	0,67	0,08	0,08	-	2000
		11 Mode	g/test	19,0	2,20	1,40	-	
	Medium Commercial Vehicle (1,7 t < GVW ≤ 3,5 t)	10-15 Mode	g/km	2,10	0,08	0,13	-	2001
		11 Mode	g/test	24,0	2,20	1,60	-	
New Long Term	Passenger Car	Combined Mode	g/km	1,15	0,05	0,05	-	2005
	Mini Commercial Vehicle			4,02	0,05	0,05	-	2007
	Light Commercial Vehicle (GVW ≥ 1,7 t)			1,15	0,05	0,05	-	2005
	Medium Commercial Vehicle (1,7 t < GVW ≤ 3,5 t)			2,55	0,05	0,07	-	2005
Post New Long Term	Passenger Car	Combined Mode	g/km	1,15	0,05	0,05	0,005	2009
	Mini Commercial Vehicle			4,02	0,05	0,05	0,005	2009
	Light Commercial Vehicle (GVW ≥ 1,7 t)			1,15	0,05	0,05	0,005	2009
	Medium Commercial Vehicle (1,7 t < GVW ≤ 3,5 t)			2,55	0,05	0,07	0,007	2009

[1] HC used for New Short Term

[2] PM limit applied only for direct injection gasoline engines equipped with NOx adsorber

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EMISSION STANDARDS - DIESEL VEHICLES

		Test Mode	Unit	CO	NMHC [1]	NOx	PM	Year
New Short Term	Passenger Car (VW ≤ 1.265 kg)	10-15 Mode	g/km	0,63	0,12	0,28	0,052	2002
	PC (VW > 1.265 kg)			0,63	0,12	0,30	0,056	2002
	Light Commercial Vehicle (GVW ≥ 1,7 t)			0,63	0,12	0,28	0,052	2002
	Medium Commercial Vehicle (1,7 t < GVW ≤ 3,5 t)			0,63	0,12	0,49	0,06	2003
New Long Term	Passenger Car (VW ≤ 1.265 kg)	Combined Mode	g/km	0,63	0,024	0,14	0,013	2005
	Passenger Car (VW > 1.265 kg)			0,63	0,024	0,15	0,014	2005
	Light Commercial Vehicle (GVW ≥ 1,7 t)			0,63	0,024	0,14	0,013	2005
	Medium Commercial Vehicle (1,7 t < GVW ≤ 3,5 t)			0,63	0,024	0,25	0,015	2005
Post New Long Term	Passenger Car	Combined Mode	g/km	0,63	0,024	0,08	0,005	2009
	Light Commercial Vehicle (GVW ≥ 1,7 t)			0,63	0,024	0,08	0,005	2009
	Medium Commercial Vehicle (1,7 t < GVW ≤ 3,5 t)			0,63	0,024	0,15	0,007	2009

[1] HC used for New Short Term

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OTHER REQUIREMENTS

Combined 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 From Oct 2011: JC08 mode hot start x 0,75 + JC08 mode cold start x 0,25
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 Small car (K-car): 60.000 km
Evaporative Emissions - Gasoline and LPG		Test similar to EC 2000 Evap test: Test limit: 2,0 g/test 1 hr hot soak at 27± 4°C HSL test + 24 hr 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. EU/US OBD standards to be accepted as equivalent
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)

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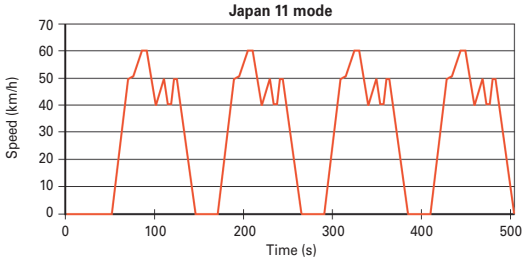
DRIVING CYCLES

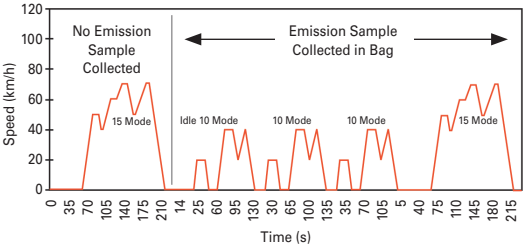
11 MODE COLD CYCLE



Distance: 4.084 km Max. Speed: 60 km/h
Duration: 480 s Average speed: 30,6 km/h

10-15 MODE HOT CYCLE

Japan 10-15 Exhaust Emission & Fuel Economy Driving Schedule
Duration 892 s - Distance 6,34 km - Average Speed 25,61 km/h
(Preceeded 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 Duration: 660 s Max. Speed: 70 km/h Average speed: 22,7 km/h

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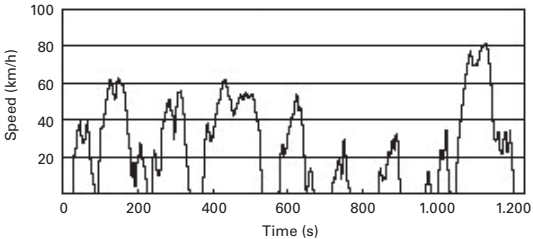
DRIVING CYCLE JC 08



Distance: 8,2 km
Duration: 1205 s

Max. Speed: 80 km/h
Average speed: 24,4 km/h

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VEHICLE CATEGORIES

Category 1: Mini-car < 800 cc
Category 2: Small PC 800 cc < PC, GVW ≤ 3,5 t, 8 seats
Category 3: Mid PC 800 cc < PC, GVW ≤ 3,5 t, 9-15 seats
Category 4: 800 cc < Small commercial car, GVW ≤ 2 t
Category 5: 800 cc < Mid commercial car (Van), GVW ≤3,5 t

From 01 Jan 2009, new vehicle categories:
Mini-car < 1.000 cc
Small PC ≥ 1.000 cc, GVW < 3,5 t, 8 seats max.
Medium PC ≥ 1.000 cc, GVW < 3,5 t, 9 seats min.
Small commercial car ≥ 1.000 cc, GVW < 2 t
Medium commercial car ≥ 1.000 cc, 2 t ≤ GVW < 3,5 t

Gasoline Emission Standards

From 01 Jul 2002
NLEV + OBD II Gasoline: Phase-in 2003-2006 (25-100%)
Emission limits PC: CO: 2,61, Cold CO: 6,3, NOx: 0,19, NMHC: 0,056 g/km
HC SCHED US: 1 g/test

From 2006

	Category	Dura.	Exhaust Emission [g/km]			Evap [g/test]	Remarks
			NMOG	CO	NOx	HC	
KULEV	KULEV	5 yr / 80 K	0,025	1,06	0,031	1,0 (SHED)	Phase-in: 2006-2009
		10 yr / 160 K	0,034	1,31	0,044		(25-100%), Cold CO: 6,3 g/km
K-LEV II	LEV		0,056	2,61	0,044		[1] for FAS calculation
			(0,047) [1]	(2,11) [1]	(0,031) [1]	2,0 (1 day DBL) →	HCHO: 0,007 g/km (0,005)*
						1,2 (2 day DBL)	PM for GDI: 0,004 g/km
	ULEV	10 yr / 192 K	0,034	1,31	0,044		2014 (New), 2015 (All GDI)
			(0,025) [1]	(1,06) [1]	(0,031) [1]		
	SULEV		0,00625	0,625	0,0125		
	ZEV		-	-	-	-	Cold CO: 6,3 g/km
	NMOG FAS Phase-in						

	2009 - Jun 2012	Jul 2012 - 2013	2014	2015
NMOG	0,025	0,024	0,023	0,022

K-LEV III		NMOG+NOx	CO	PM	HC	
	LEV160		0,100	2,61		0,35 (2 day DBL)	Cold CO: 6,3 g/km
	ULEV125		0,078	1,31		Real D.F should	
	ULEV70		0,044	1,06	0,002	be submitted	K-LEV III regulation is
	ULEV50	15 yr / 240 K	0,031	1,06		EPA temperature	same as US LEV III
	SULEV30		0,019	0,625		profile is used	
	SULEV20		0,0125	0,625			
	ZEV		-		-	-	

K-LEV III from Jan 2018 (Phase-in until 2022)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Phase-in	0	0	30	30	80	80	100	100	100	100

NMOG + NOx FAS Phase-in for CVS-75 mode only

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
NMOG+ NOx	0,063	0,058	0,053	0,048	0,043	0,039	0,034	0,039	0,024	0,019

- Enforcement is delayed 1year compared to US LEV III

SOUTH KOREA

Diesel Emissions Standards

From 01 Jul 2002
Emission limits PC: CO: 0,5, NMHC: 0,01, NOx: 0,02, pm: 0,01 g/km
K-ULEV diesel applications: GVWR ≤ 2,5 t
Euro 4 from 01 Sep 2009
Current regulation Regulation(MY2016)
Euro 6-b (or Euro 6-1)
Small, Mid PC
→ HC+NOx 0,170, NOx 0,080, CO 0,50, PM 0,0045 g/km, PN 6 X 10^{11}#/km at 160.000 km
→ From 01 Jan 2014
Small & Mid commercial car
1) RW ≤ 1.305 kg
HC+NOx 0,170, NOx 0,080, CO 0,50, PM 0,0045 g/km, PN 6 X 10^{11}#/km at 160.000 km
2) 1.305 kg < RW ≤ 1.760 kg
HC+NOx 0,195, NOx 0,105, CO 0,63, PM 0,0045 g/km, PN 6 X 10^{11}#/km at 160.000 km
3) RW > 1.760 kg
HC+NOx 0,215, NOx 0,125, CO 0,74, PM 0,0045 g/km, PN 6 X 10^{11}#/km at 160.000 km
Large PC & commercial car
HC+NOx 0,13, NOx 0,40, CO 1,5, PM 0,01 g/kWh, PN 8 X 10^{11}/kWh
Super large PC & commercial car
HC+NOx 0,16, NOx 0,46, CO 14,0, PM 0,01 g/kWh, PN 6 X 10^{11}/kWh

K-OBD Standards

K-OBD for PC:
Gasoline Category 1,3,4,5: 01 Jan 2006 (New Model), 01 Jan 2007 (All Model)
Gasoline Category 2: 10% (CY05), 30% (CY06), 100% (CY07)
Diesel Category 1,2,3,4,5: 01 Sep 2014 (New Model), 01 Sep 2015 (All Model)
- NOx 0,18, CO 1,75, NMHC 0,29, PM 0,025 g/km
at 160.000 km (Euro 6b regulation)

K-CAFE Standards

Next emission regulation:
Diesel Euro 6
Mini-PC, small PC and small commercial vehicle
HC+NOx 0,170, NOx 0,080, CO 0,50, PM 0,0045 g/km at 160.000 km
01 Sep 2014 (New Model), 01 Jan 2015 (All Model)
Mid PC, mid commercial car
01 Sep 2015 (New Model), 01 Jan 2016 (All Model)
Gasoline: CARB LEV II from Jan 2009 (phase-in until 2015)
Introduction of NMOG FAS (Fleet Average System) for PC and Truck ≤ 1,7 t
2009-Jun 2012: 0,025, Jul 2012-2013: 0,024, 2014: 0,023, 2015: 0,022
PM limit for GDI: 0,004 g/km, 2014 (New Model), 2015 (All GDI)
Evaporative emission: 1hr hot soak + 2 days DBL: 1,2 g/test
Durability: Diesel should follow EU 5 / EU 6
Gasoline extension to 10 years or 192.000 km

BRAZIL

Fixed Deterioration Factors (DF) from Jan 2002:
CO and HC 20%, NOx 10%
Only valid if annual production is < 15.000 vehicles
Durability: 80.000 km or 5 years
SHED Proconve L6: 1,5 g/test

Certification required with
E22 fuel for E22 vehicle
E22 / E60 / E100 and CNG for a "tri" fuel vehicle
Highway Cycle Test (E22 and E100 fuels - ABNT NBR 7024)

ON-BOARD DIAGNOSTICS

OBDBr-1	Continuity monitoring only - main actuators and sensors
OBDBr-2	OBDBr-1 + Misfire, O2 Reponse and Cat Mon diagnostics No Fuel System Diagnostics O2 Reponse and Cat Mon required only in % ethanol ranges of 19-30% and 90-100%
OBDBr-2+	O2 Reponse and Cat Mon required in all % ethanol ranges New CO Limit
OBDBr-D	OBD Diesel for Light Passenger Vehicle & Light Commercial Vehicle ≤ 3.856 kg Normative instruction n°5 - 06 Feb 2013

BRAZIL

STANDARDS FOR GASOLINE PC, LCV AND DIESEL LCV
PROCONVE L7 in proposal phase

	CY		NMHC	CO	NOx ( ) Diesel limits	HCHO	PM [1]
PC	2009+	PROCONVE L5	0,05	2,00	0,12	0,020	
	2014+	PROCONVE L6	0,05	1,30	0,08	0,020	0,025
	2020+	PROCONVE L7 (expected)	0,05	1,30	0,03	0,010	0,005
LCV (≤ 1.700 kg)	2009+	PROCONVE L5	0,05	2,00	0,12 (0,25)	0,020	0,050
	2014+	PROCONVE L6	0,05	1,30	0,08 (0,08)	0,020	0,025
	2020+	PROCONVE L7 (expected)	0,05	1,30	0,03	0,010	0,005
LCV (> 1.700 kg)	2009+	PROCONVE L5	0,06	2,70	0,25 (0,43)	0,040	0,060
	2014+	PROCONVE L6	0,06	2,00	0,25 (0,35)	0,030	0,040
	2020+	PROCONVE L7 (expected)	0,05	1,30	0,05	0,015	0,010

All tables values in g/km - (THC) only for natural gas powered vehicles: 0,30 g/km (PC & LCV ≤1.700 kg) and 0,50 g/km (LCV > 1.700 kg) - Carbon Monoxide at idle speed for Otto cycle: 0,2% in volume
[1] Particulate Matter (PM) only for Diesel Cycle

Phase-in Requirements (% of total PC + LCV)

	CY 2012	CY 2013	CY 2014	CY 2015	CY 2016	CY 2017	CY 2018	CY 2019	CY 2020	CY 2021
PROCONVE L5	100%	100%								
PROCONVE L6			100%	100%	100%	100%	100%	100%		
PROCONVE L7 (expected)									100%	100%

BRAZIL

PHASE-IN REQUIREMENTS

	CY 2014	CY 2015	CY 2016	CY 2017	CY 2018
OBDBr-2	100%	100%	100%		
OBDBr-2+				100%	100%
OBDBr-D		100%	100%	100%	100%

OBD EMISSION THRESHOLDS

OBDBr-2	THC [1]	NMHC [2]	CO	NOx
PC	0,75	0,3	4,11	0,75
LDT ≤ 1.700 kg [3]	0,75	0,3	4,11	0,75
LDT > 1.700 kg [3]	1,25	0,5	8,22	1,5

OBDBr-D	NMHC	CO	NOx	MP
PC	0,30	2,40	0,30	0,30
LCV ≤ 1.700 kg [3]	0,30	2,40	0,30	0,30
LCV > 1.700 kg [3]	0,35	3,20	1,00	0,40

PC Passenger Car
LCV Light Commercial Vehicle < 3.856 kg
LDT Light Duty Truck

OBDBr-2+	THC [1]	NMHC [2]	CO	NOx
PC	0,75	0,3	3,0	0,75
LDT ≤ 1.700 kg [3]	0,75	0,3	3,0	0,75
LDT > 1.700 kg [3]	1,25	0,5	6,0	1,5

[1] Only for LPG vehicles
[2] Only for Spark Ignition Vehicles except LPG
[3] Mass of the vehicle for the emission test

OTHER AREAS OF THE WORLD

Argentina		Standard	New models		All Models
		Euro 4	2009		2011
		Euro 5a	2015 [a]	2016 [b]	2017 [a] 2018 [b]
	a) Vehicles category M1 with GVW ≤ 2500 kg b) Vehicles category M1 with GVW > 2500 kg and vehicles category N1				
Australia	M1 (≤ 3,5 t)	Euro 5a	Nov 2013		Nov 2016
		Euro 6	Jul 2017		Jul 2018
Canada	There will be a harmonization with the emission standards of the US EP Tier 3 program, starting with 2017 MY. Most of the Tier 3 provisions are harmonized with the US Tier 3 requirements, however differences exist in the phase-in of the standards. For instance, 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 LDT (2010)				
Chile	Since MY 2005/2006, there are two alternative emission compliance options: 1) US-based emission standards: EPA Tier 2 Bin 5 based standards effec. 2013/2014 2) European-based emission standards: Euro 5 based standards effec. 2013/2014 No OBD requirements are indicated in Chile's emission standards.				

PR of China	**Nationwide**		
	CN4	LD vehicle	TA: 01 Jul 2010 FR: 01 Jul 2011
		LD Diesel vehicle	Postponed to 01 Jan 2015
		HD vehicle	TA: 01 Jan 2010 FR: 01 Jan 2011
		HD Diesel vehicle	Postponed to 01 Jan 2015
	CN5	LD Diesel	TA: 17 Sep 2013 FR: 01 Jan 2018
		HD Diesel (public transit & service)	TA: 01 Jan 2012 FR: 01 Jan 2017
		HD Diesel (all)	TA: 01 Jan 2012 FR: 01 Jul 2017
		Gasoline	TA: 17 Sep 2013 FR: 01 Jan 2017
		CN5 Fuel (both Diesel & Gas)	From 01 Jan 2017
		Durability requirements:	
		CN3: 80.000 km CN4: 100.000 km CN5: 160.000 km	
	CN3	Gasoline (150 ppm sulfur)	31 Dec 2009
	CN4	Gasoline (50 ppm sulfur)	31 Dec 2013
	CN5	Gasoline (10 ppm sulfur)	01 Jan 2017
	CN4	Diesel (50 ppm sulfur)	Before 31 Dec 2014
	CN5	Diesel (10 ppm sulfur)	Before 31 Dec 2017 (proposed)
	East of China (incl. 11 provinces)		
	CN5	LD Diesel Passenger Car	TA: 17 Sep 2013 FR: 01 Apr 2016
	CN5	HD Diesel (public transit & service)	TA: 01 Jan 2012 FR: 01 Apr 2016
	CN5	Gasoline	TA: 17 Sep 2013 FR: 01 Apr 2016
	CN5	Fuel (both Diesel & Gas)	From 01 Jan 2016

OTHER AREAS OF THE WORLD

PR of China (contd.)	**Beijing**		
	CN4	Gasoline AND Diesel (LD)	From 01 Mar 2008
	CN4	Diesel HD	From 01 Jul 2008
	CN5	Gasoline (without IUPR)	From 01 Feb 2013
	CN5	Gasoline (with IUPR)	From 01 Jan 2015
	CN5	Diesel	From 01 Feb 2013
	CN5	HD Diesel	From 01 Jan 2015
	CN5	Fuel (max.sulfur 10 ppm) Both Diesel/Gas	From 31 May 2012
	Guangzhou		
	CN4	Gasoline AND Diesel (LD)	From 01 Mar 2008
	CN5	Gasoline AND Diesel (LD)	From 31 Dec 2015
	Hong Kong		
	Passenger Cars (2.500 kg)		
	CN4	Gasoline	CARB LEV II or Japan 2005 From 2006
	CN5		Planned for 2011
	CN5	Diesel	Diesel From 2009
	Shanghai		
	CN4		
	CN4	Diesel (max. sulfur 50 ppm)	From 01 Jul 2013
	CN4	Gasoline (max. sulfur 50 ppm)	From 01 Oct 2009
	CN5	Gasoline AND Diesel (LD) Diesel	From 01 May 2015
		Urban vehicle for WHTC	From 01 Jan 2015

Iceland	EU legislation applied			
India	Indian test cycle: max speed is 90 km/h compared to 120 km/h for the NEDC			
	Bharat Stage IV - Euro 4	From Apr 2010	National Capital Region (Dehli), 13 cities	
		From Jul 2015	Above + plus 29 cities	
		From Oct 2015	North India + bordering districts of Rajasthan (9 States)	
		From Apr 2016	Western India plus + South and East India (10 States and Territories)	
		From Apr 2017	Nationwide	
	Bharat Stage V - Euro 5	From Apr 2019 for new models, Apr 2020 for exisiting models		Nationwide
	Bharat Stage VI - Euro 6	From Apr 2021 for new models, Apr 2022 for exisiting models		Nationwide
Indonesia	Euro 2	New Models	Jan 2005	
		Existing Models	Jan 2007	
Mexico	Tier II (Euro 4 option) phase-in Fuel economy and CO_2 regulation mandates a light duty fleet average of 14,9 km/l in 2016 (new vehicles only)			

OTHER AREAS OF THE WORLD

New Zealand	Same vehicle categories as Australia New vehicles	Euro 5 (US and Japanese standards are alternatives)	
Philippines	Administrative Order No.2010-23 also states that starting in Jan 2016, all new passengers cars and LD vehicles will be required to meet Euro 4 emission standards, subject to 50 ppm sulfur fuel availability		
Russia	Euro 3 (ECE R83.05 Stage III) Euro 4 (ECE R83.05 Stage IV) Euro 5		From Jan 2008 From Jan 2014 From Jan 2016
Saudi Arabia	Euro 2 Euro 3 (proposal) (UN ECE Reg 83/05)		As of MY 2004 As of TBD
South Africa	Euro 1 Euro 2	Feb 2005 (new models) Jan 2006 (new models), Jan 2008 (existing models)	
Switzerland	Has harmonised national requirements on EU requirements		
Thailand	Euro 4 Euro 4	Since Jan 2012 From Jan 2013	

Turkey	**DOMESTIC VEHICLES**	new vehicles	all vehicles
	- Euro 1 - M1 Diesel	2001	2002
	- Euro 3 - M1 Gasoline, no OBD	2001	2002
	- Euro 4	2008	2009
	- Euro 5 - M1, N1 Class 1; N1 Class 2/3 from 2012	2010	2011
	IMPORTED VEHICLES	Must comply with current EU standards	
Ukraine	Euro 6 (proposal)	2018	

EUROPEAN ON-BOARD DIAGNOSTICS

EURO 3-4

It identifies malfunctions and deterioration that cause emissions to exceed thresholds, based European revised urban + extra urban cycle.
Driver is notified upon detection.
On-board diagnostics was first introduced with Euro 3 emission limits (M1 ≤ 2,5 t GVW; LDT N1 CL1 TA: 01 Jan 2000 / FR: 01 Jan 2001)

EOBD Thresholds Euro 3-4 (g/km)	CO		HC		NOx		PM
	Gasoline LPG/NG	Diesel	Gasoline LPG/NG	Diesel	Gasoline LPG/NG	Diesel	Diesel
M1 ≤ 2,5 t GVW, LDT N1 CL 1	3,20	3,20	0,40	0,40	0,60	1,20	0,18
LDT N1 CL 2	5,80	4,00	0,50	0,50	0,70	1,60	0,23
LDT N1 CL 3, M1 > 2,5 t GVW	7,30	4,80	0,60	0,60	0,80	1,90	0,28

Monitor area	Gasoline	Diesel
Catalyst converter (gasoline THC only)	X	X
Engine misfire	X	
Oxygen sensor deterioration	X	
Particulate trap		X

Monitor area	Gasoline	Diesel
Fuel injection system	X	X
Circuit continuity of all emission related powertrain components	X	X

Monitor area	Gasoline	Diesel
Any other emissons related components or systems (air flow, EGR,eg) if malfunction causes increase above thresholds	X	X

No OBD Euro 4 step was foreseen.

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

(mg/km)

EOBD Thresholds	Implementation Dates		CO		NMHC		NOx		PM	
Euro 5	TA	FR	PI	CI	PI	CI	PI	CI	PI [1]	CI [2]
M, LDT N1 CL 1	01 Sep 2009	01 Jan 2011	1.900	1.900	250	320	300	540	50	50
LDT N1 CL 2	01 Sep 2010	01 Jan 2012	3.400	2.400	330	360	375	705	50	50
LDT N1 CL 3, N2	01 Sep 2010	01 Jan 2012	4.300	2.800	400	400	410	840	50	50

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 cat (in addition to front sensor)
PM monitoring [3]
IUPR (> Euro 5+) [4]

[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
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)

[4] Euro 5+ OBD TA: 01 Sep 2011 / FR: 01 Jan 2014

EUROPEAN ON-BOARD DIAGNOSTICS

EURO 6 OBD REQUIREMENTS

(mg/km)

EOBD Thresholds	Implementation Dates		CO		NMHC		NOx		PM	
Euro 6-1	TA	FR	PI	CI	PI	CI	PI	CI	PI	CI
M, LDT N1 CL1	01 Sep 2014	01 Sep 2015	1.900	1.750	170	290	150	180	25	25
LDT N1 CL 2	01 Sep 2015	01 Sep 2016	3.400	2.200	225	320	190	220	25	25
LDT N1 CL 3, N2	01 Sep 2015	01 Sep 2016	4.300	2.500	270	350	210	280	30	30
Euro 6-2	TA	FR	PI	CI	PI	CI	PI	CI	PI	CI
M, LDT N1 CL1	01 Sep 2017	01 Sep 2018	1.900	1.750	170	290	90	140	12	12
LDT N1 CL 2	01 Sep 2018	01 Sep 2019	3.400	2.200	225	320	110	180	12	12
LDT N1 CL 3, N2	01 Sep 2018	01 Sep 2019	4.300	2.500	270	350	120	220	12	12

Demonstration Cycle Proposal (status February 2016)

- OEM flexible to choose NEDC or WLTP cycle for OBD threshold part creation as well as for demonstration testing during a transition phase
- Transition phase duration still to be defined
- After the transition phase end only WLTP cycle is applicable

EUROPEAN ON-BOARD DIAGNOSTICS

Additional requirement starting Euro 5+ [1]: In Use Performance Ratio 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/6d		
Catalyst	-	-	0,1	PI	CI	PI	CI	Denominator
EGR system	-	-	0,1	0,336	0,336	0,336	0,336	
O2 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	0,26	
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 oxydation 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

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US ON-BOARD DIAGNOSTICS

Similar to the existing Diesel specific table (see page 52) a new table for gasoline vehicles was introduced. Beginning of 2017 the EPA Tier III requirements are harmonized with Carb requirements (see page 46). Minor exceptions are outlined in the EPA section.

EPA OBD II - EPA HARMONIZATION FINAL RULE MY 2001 ONWARDS

Monitor Area	Condition for Malfunction
Catalysts Engine Misfire, O2 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 - Evaporative Systems 0,020" leak detection: phase-in allowed if manufacturer begins in 2016 MY and achieves ≥ 100% by 2018+ MY (while never reducing compliance % within those MY's)

US CARB OBD II - ALL 2015+ MY VEHICLES (based on CARB OBD II proposed rulemaking package - 08 Aug 2015)

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°F 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 subsquently drops. May disable monitor when IAT< 20°F, ECT at startup is 35°F less than malfunction threshold, or during conditions cause false results
- Engine Coolant Temperature Sensor	a) Circuit continuity b) Time to reach closed-loop/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

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 when temp gauge is based on same sensor and indicates overheating)
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 1) 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 connectin 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 Executive Officer approval: at a minimum, must monitor components used by any other system or component monitor, energy input devices, battery and charging system performance, electrical motor performance, and regenerative braking performance.

US ON-BOARD DIAGNOSTICS

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: - Component 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 circuity 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 w/o belt/chain
- Output Components	a) Improper functional response, as feasible b) Circuit continuity faults c) Idle Control System (Gasoline engines w/ 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):

Monitor Area	Condition for Malfunction
- Output Components (contd.)	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) 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: - 0,260 for secondary air system, cold start monitors, and evaporative 0,020" leak - 0,336 for catalyst, oxygen sensors, EGR, VVT, and remainder - 0,520 for low load purge flow, high 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 adsorber, NMHC Catalyst, NOx Catalyst, PM Filter, boost pressure control, NMHC Catalyst, and fuel system cylinder imbalance

US ON-BOARD DIAGNOSTICS

LEV III GASOLINE EMISSIONS THRESHOLDS

Exhaust Standards		Monitor Thresholds (except catalyst)				Catalyst Monitor Thresholds			
Vehicle Type	Vehicle Emission Category	NMOG+NOx Mult.	CO Mult.	PM Mult.	PM THD [mg/mi]	NMOG+NOx Mult.	CO Mult. [2]	PM Mult.	PM THD [mg/mi]
Passenger Cars, Light Duty Trucks and Chassis Certified MDPVs	LEV160	1,50	1,50	N/A	17,50 [2]	1,75	1,50	N/A	17,50 [2]
	ULEV125								
	ULEV70	2,00				2,00			
	ULEV50								
	SULEV30	2,50	2,50			2,50	2,50		
	SULEV20 [4]								
Chassis Certified MDVs (except MDPVs)	All MDV Emission Categories	1,50	1,50	1,50 [1]	17,50 [3]	1,75	1,50	1,50 [1]	17,50 [3]

[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)

THD = Threshold; mg/mi = milligram per mile; Mult. = Multiplier to be used with the applicable standard (e.g. 2,0 times the NMOG+NOx standard)

US ON-BOARD DIAGNOSTICS

US CARB OBD II - GASOLINE VEHICLES

Monitor Area	Condition for Malfunction
EGR (low and high flow rate) Secondary Air (low flow rate)	- For Non-LEVIII = 1,5 x std; For LEVIII = [1] - Based on increase or decrease in air flow rate - 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, ...) - For Non-LEVIII vehicles = 1,5 x std - For LEVIII vehicles - LEV160, ULEV125, MD Chassis certified = [1] - ULEV50/70 = For 2014-2018, 3 x std; For 2019+ = [1] - SULEV20/30 = For 2014-2018, 4 x 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 positive 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 hybrid 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 automatived shut-off/restart strategies must get Exec Officer approval for re-enabling conditions
Evaporative System	a) No purge flow (must monitor all purge flow paths with the EO approved exception of high loadlines on boosted systems. Such high load purge lines will also require monitoring for 20% of 2019; 50% of MY 2020 and 100% of MY 2021) 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 Executive Officer approval of a strategy equating to gasoline.

[1] Refer to Gasoline Emission Thresholds (see page 17)

Monitor Area	Condition for Malfunction
Exhaust Gas Sensors - 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-rich 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 charcteristic no longer sufficient for use as input to other monitoring strategy
- Exhaust Gas Sensor Heaters	a) Current or voltage drop no longer within sensor manufacturer's limit for normal operation b) Faults that result in conflict between commanded and actual state of the heater
Variable Valve Timing Lift, and/or Control	For Non-LEVIII = 1,5 x std. (all constituents); For LEVIII = [1)] - Target error (outside crank angle and/or lift tolerance) - Slow Response

Catalyst	Affected Vehicles	NMOG	NOx	CO Mult.	PM Mult.	PM THD	NMHC Conversion Efficiency
	Certification						
	LEVII, ULEVII, MDV SULEVII	1,75 x	1,75 x	N/A	N/A	N/A	50%
	SULEVII	2,5 x	2,5 x	N/A	N/A	N/A	50%
	LEVIII	[1)]					
	For threshold testing purposes, the catalyst system is to be aged simultaneously (full catalyst volume) - If fuel is shut off for misfiring cylinder, the monitored volume catalyst(s) must be aged simultaneously to the threshold limit, while unmonitored volume must be aged to the end of the vehicle's full useful life						

[1)] Refer to Gasoline Emission Thresholds (see page 17)

US ON-BOARD DIAGNOSTICS

US CARB OBD II - GASOLINE VEHICLES

Monitor Area	Condition for Malfunction
Cold Start Emission Reduction Strategy	a) Any single commanded element does not repond 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). [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
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 Executive 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 < 11 V, battery voltage > manuf. limit, during PTO operation, or tire pressure default action

[1] Refer to Gasoline Emission Thresholds (see page 17)

US ON-BOARD DIAGNOSTICS

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 2018+ MY - Phase-in for ALL OTHER MD VEHICLES: 20% of 2016 MY, 50% of 2017 MY, 100% of 2018+ MY 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.; LEVIII vehicles = refer to Diesel Emission Thresholds (page 17) 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

US ON-BOARD DIAGNOSTICS

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 adsorber, 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; Crankcase Ventilation; Comprehensive 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 modifed 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: ambiant temperature <20 F, altitude > 8.000 ft, vehicle speed > 82+ mph, fuel volume < 15% of capacity, battery voltage < 11 V, battery voltage > manufacturer limit, during PTO operation, or tire pressure default action 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

US ON-BOARD DIAGNOSTICS

US CARB OBD II - DIESEL VEHICLES

Monitor Area	Condition for Malfunction
NMHC Converting Catalyst (excluding downstream or PM filter for regen) - Conversion Efficiency	- Chassis certification: Non-LEVIII vehicles = 1,75 x NMHC std.; LEVIII = refer to Diesel Emission Thresholds (page 17) - MDV 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 for no malfunction able to increase emissions by 15% of full useful life standard AND does not exceed the full useful life standard) 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
NOx Converting Catalyst - Conversion Efficiency	- Chassis Certification: Non-LEVIII = 1,75 x std (NOx or NMHC); LEVIII vehicles = refer to Diesel Emission Thresholds (page 17) MDV Certified on Engine Dynamometer: - 2016 + MY: 2,0 x NMHC standard; NOx 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

US ON-BOARD DIAGNOSTICS

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

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

Monitor Area	LDV and MDV (Chassis Cert.) Threshold					MDV (Engine Cert.) Threshold				
	MY	NMHC	CO	NOx	PM	MY	NMHC	CO	NOx	PM
NOx Adsorber	2013+	1,75 x	-	1,75 x	-	2013+	2,0 x	-	+0,2	-
Exhaust Gas Sensor Performance	2013+	1,5 x	1,5 x	1,75 x	2,0 x	2013-2015	2,0 x	-	+0,3	0,03
NOx and PM sensors		-	-	-	-	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	See page 59				
Boost Pressure Ctrl (under & over) Variable Geometry Turbocharger (VGT) Resp., Charge Air Undercool.	2013+	1,5 x	1,5 x	1,5 x	2,0 x	2013+	2,0 x	2,0 x	+0,2	0,03

US ON-BOARD DIAGNOSTICS

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

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

Monitor Area	LDV and MDV (Chassis Cert.) Threshold					MDV (Engine Cert.) Threshold				
	MY	NMHC	CO	NOx	PM	MY	NMHC	CO	NOx	PM
Cold start	Fault due to control strategy input error(s) and/or output error (2013+ Monitor for desired effect as feasible)									
Emission Reduction Strategy	2013+	1,5 x	1,5 x	1,5 x	2,0 x	2013+	2,0 x	2,0 x	+0,2	0,03
Variable Valve TrainTiming and/or Control (VVT) Target Error Slow Response	2013+	1,5 x	1,5 x	1,5 x	2,0 x	See page 59				
Particulate Matter Filter	2013+	-	-	-	1,75 x	2013+	-	-	-	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 Conversion	2015+	1,5 x	1,5 x	1,5 x	-	2015+	2,0 x	-	+0,2	-
	(exemption for no malfunction able to increase emissions by 15% 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 emissions increase of 15% of applicable full useful life standard AND no malfunction results in exceeding the full useful life standard								
Aftertreatment Assistance Function	2010 + loss function (LEV III Proposal: Feedgas required 2015+)					2010 + loss function				

US ON-BOARD DIAGNOSTICS

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

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

Monitor Area	MY	LDV and MDV (Chassis Cert.) Threshold				MDV (Eng. Cert.) Threshold NOx cert. > 0,50 g/bph-hr				MDV (Eng. Cert.) Threshold NOx cert. ≤ 0,50 g/bph-hr			
		NMHC	CO	NOx	PM	NMHC	CO	NOx	PM	NMHC	CO	NOx	PM
Fuel System Pressure Control	2013+	1,5 x	1,5 x	1,5 x	2,0 x	1,5 x	1,5 x	1,5 x	0,03	2,0 x	2,0 x	+0,2	0,03
Fuel System Injection Quantity / Timing	2013+	1,5 x	1,5 x	1,5 x	2,0 x	Same Fault Criteria as Fuel System Pressure Control							
Fuel Control System using Tolerance compensation features	2015+ 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+	1,5 x	1,5 x	1,75 x	2,00 x	?	?	?	?	2,0 x	2,0 x	+0,2	0,03
Upstream Exhaust Gas Sensor Performance A/F Sensors	2013+	1,5 x	1,5 x	1,5 x	2,0 x	1,5 x	1,5 x	1,5 x	0,03	2,0 x	2,0 x	+0,2	0,03
EGR Catalyst	2013+	No detectable amount of constituent oxidation (monitoring not required for no measurable emission impact under any reasonable driving condition)											

US ON-BOARD DIAGNOSTICS

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

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

Monitor Area	MY	MDV (Eng. Cert.) Threshold NOx cert > 0,50 g/bhp-hr				MDV (Eng. Cert.) Threshold NOx cert ≤ 0,50 g/bhp-hr			
		NMHC	CO	NOx	PM	NMHC	CO	NOx	PM
EGR Low Flow, High Flow, Response Cooler Performance	2013+	1,5 x	1,5 x	1,5 x	0,03	2,0 x	2,0 x	+0,2	0,03
Variable Valve Train Target Error Slow Response	2013+	1,5 x	1,5 x	1,5 x	0,03	2,0 x	2,0 x	+0,2	0,03

US ON-BOARD DIAGNOSTICS

LEV III OBD II DIESEL PM FILTER

Exhaust Standards		DPF Filtering Performance Monitoring Threshold			
Vehicle Type	Vehicle Emission Category	NMOG+NOx Mult. [1]	CO Mult. [1]	PM Mult.	PM THD (mg/mi)
Passenger Cars, Light Duty Trucks and Chassis Certified MDPVs	LEV160	1,50	1,50	N/A	17,50
	ULEV125				
	ULEV70	2,00			
	ULEV50				
	SULEV30	2,50	2,50		
	SULEV20 [4]				
2016 MY - 2018 MY Chassis Certified MDPVs (except MDPVs)	All MDV Emission Categories	N/A	N/A	1,75 [2]	17,50 [3]
2019+ MY Chassis Certified MDVs (except MDPVs)	All MDV Emission Categories	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

[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

[4] Manufacturer shall use the 2.5 times NMOG + NOx multiplier for vehicles not using the provisions of section (f)(17.1.7)

US ON-BOARD DIAGNOSTICS

LEV III OBD II DIESEL REQUIREMENTS

Exhaust Standards		Monitor Thresholds [1]			Aftertreatment Monitor Thresholds [2]		
Vehicle Type	Vehicle Emission Category	NMOG+NOx Mult.	CO Mult.	PM Mult.	NMOG+NOx Mult.	CO Mult. [3]	PM Mult.
Passenger Cars, Light Duty Trucks and Chassis Certified MDPVs	LEV160	1,50	1,50	2,00	1,75	1,50	2,00 [3]
	ULEV125						
	ULEV70	2,00			2,00		
	ULEV50						
	SULEV30	2,50	2,50		2,50	2,50	
	SULEV20 [6]						
2016 MY - 2018 MY Chassis Certified MDPVs (except MDPVs)	All MDV Emission Categories	1,50	1,50	2,00	1,75	N/A	N/A
Chassis Certified MDVs (except MDPVs)	All MDV Emission Categories	1,50	1,50	1,50 [4] or 2,00 [5]	1,75	1,50	1,50 [4] or 2,00 [5]

1) Applies to (f)(3.2.5). (f)(4)-(f)(7). (f)(9.2.2). (f)(12)-(f0(13
2) Applies to (f)(1)-(f)(2). (f)(8). And (f)(9.2.4)(A)
3) Applies to 2019 and subsequent MY
4) Applies to vehicles not included in the phase-in of the PM standards set forth in Title 13, CCR section 1962.2(a)(2)(B)2
5) 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
6) Manufacturer shall use the 2.5 times NMOG + NOx multiplier for vehicles not using the provisions of section (f)(17.1.7)

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FUEL CONSUMPTION - CO_2 EMISSIONS

EUROPEAN UNION

EU REGULATION ON CO_2 EMISSION REDUCTION FOR PASSENGER CAR (M1)

EC 443/2009 regulates the average specific emissions of CO_2 for each manufacturer for new passenger vehicles which are registered in the EU in each CY.
Permitted specific emissions of CO_2 = 130 [g/km] + 0,0457 * (vehicle mass [kg] - 1.372 [kg])
1.372 [kg] = reference mass. to be reviewed every 3 years (2015 for the 1st time)

- Fleet average CO_2 emissions from new PC: 120 g/km by 2012
  (NEDC driving cycle)
  - Max 130 g CO_2/km based on improvements in vehicle motor technologies
  - Complementary measures to deliver a further 10 g/km reduction
    (tires, air conditioning, greater use of alternative energy)
- 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 in each manufacturer's average specific target 1 g CO_2/km is the minimum a single eco-innovation can contribute. Eco-innovations are approved as part of the vehicle
- For each manufacturer, individual targets based on average mass of their EU car fleet, based on an emission limit curve
- Excess emissions penalties are applied. The premium is based on the # of g/km above the curve multiplied by the number of vehicles sold 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)
- 2020 target: 95 g CO_2/km in 2021 (application of WLTP after 2017 (TBD), no change of 95 g/km CO_2 goal foreseen but tool to be developed to correlate CO_2 emissions from NEDC to WLTC ("isosevere" correlation)

Phase-in: 95% of fleet in 2020, 100% by Jan 2021.
Super credits can be used up to 7,5 g/km for 1 year between 2020-2022

FUEL CONSUMPTION - CO_2 EMISSIONS

EUROPEAN UNION

VEHICLES WITH MASSES DIFFERENT FROM 1.372 KG MAY EMIT CO_2 ACCORDING TO THE FOLLOWING FORMULAS

From 2012-2015:

CO_2 = 130 + 0,0457 x (M-Mo)

Mo = 1.372 kg (this mass corresponds to the average mass of the current global European fleet)

From 2016:

CO_2 = 130 + 0,0457 x (M-Mo)

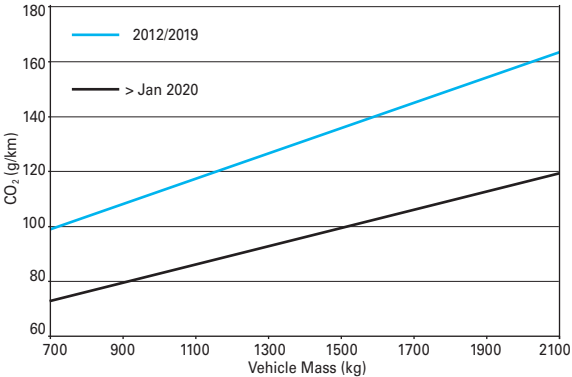
Mo = 1.393 kg (average mass of all vehicles registered between Jan 2013-Dec 2015)

From 2020:

CO_2 = 95 + 0,0333 x (M-Mo)

Mo = average mass of all vehicles registered between Jan 2017-Dec 2019

EU CO_2 to Vehicle Mass Radio



FUEL CONSUMPTION - CO_2 EMISSIONS

US

The US has 2 sets of parallel standards :

1. CAFE - Corporate average standards adopted by NHTSA
2. GHG - Green House Gas standards adopted by the EPA

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 thru 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 polutant 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 isued 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. The MTE will commence in early 2016 and issue a final dermination by April 2018 with final standards to follow.
- Under CAFE, manufacturers could pay fees instead of meeting standards. Under the Clean Air Act manufacturers must comply with CO_2 standards amd cannot pay non compliance fees. EPA established a Temporary Lead-Time Allowance Alternative Standards (TLAAS) for additional transition time.

2012-2016 STANDARDS

The 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.

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
	CO_2 equiv. mpg	33,8	34,7	36,0	37,7	39,5
	CAFE mpg	33,3	34,2	34,9	36,2	37,8
Light Trucks	CO_2 g/mi	346	337	326	312	298
	CO_2 equiv. mpg	25,7	26,4	27,3	28,5	29,8
	CAFE mpg	25,4	26,0	26,6	27,5	28,8
Combined Cars & Trucks	CO_2 g/mi	295	286	276	263	250
	CO_2 equiv. mpg	30,1	31,1	32,2	33,8	35,5
	CAFE mpg	29,7	30,5	31,3	32,6	34,1

The standards are 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).

FUEL CONSUMPTION - CO_2 EMISSIONS

US

N_2O and CH_4 Standards. In addtion 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 - CH4: 0,030 g/mile

Flexibilities. The regulation also include 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.

2017-2025 STANDARDS

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
	CO_2 equiv. mpg	41,9	44,0	46,5	48,8	51,7	54,2	56,6	59,3	62,2
	CAFE mpg [1]	39,4	41,3	43,5	45,6	47,5	48,6	49,8	51,4	52,5
Light 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
	CAFE mpg [1]	29,0	29,8	31,6	33,0	35,1	35,8	36,6	37,6	38,3
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
	CAFE mpg [1]	34,9	36,3	38,4	40,4	42,3	43,4	44,4	45,8	46,8

[1] Estimated average achieved compliance levels, reflecting all flexibilities, credits and penalty payments

Flexibilities. 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

FUEL ECONOMY TESTING

MY 2011 and beyond.

- EPA 5-cycle test - based upon combination of FTP-75, HWFET, cold FTP (20F) US06, SCO3
- MPV (8.500-10.000 GVWA) require FF label for first time
- See 40CFR, Chapter 1, Subchapter Q, Part 600. 113 and 114 for fuel economy, CO_2 emissions and EPA 5-cycle test calculations

FUEL CONSUMPTION - CO_2 EMISSIONS

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.
- These regulations were initially challenged by the auto industry as regulatory overreach. EPA approved the measures.
- In February 2010 California adopted regulations that allow cars that comply to Federal 2012-2016 to comply with CARB standards. The 2 standards differ slightly, but reach the same levels by 2016.
- EPA and CARB GHG regulations are harmonized from 2017-2025.

California fleet average GHG emission standards					
Time Frame	Year	GHG Standard, g CO_2/mi (g CO_2/km)		CAFE Equivalent, mpg (l/100 km)	
		PC/LDT1	LDT2	PC/LDT1	LDT2
Near Term	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)
Medium Term	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)

JAPAN

CO_2 REDUCTION REGULATION

Fuel Economy Targets

- Each manufacturer has to achieve the fuel efficiency as a weighted average in each weight class.
- Consumption determined on 10-15 cycle

Vehicle weight (kg) - Fuel Economy (km/l)

Gasoline Passenger Cars - Targets for 2010								
< 702	703 - 827	828 - 1.015	1.016 - 1.265	1.266 - 1.515	1.516 - 1.765	1.766 - 2.015	2.016 - 2.265	2.266 -
21,1	18,8	17,9	16,0	13,0	10,5	8,9	7,8	6,4
Diesel Passenger Cars - Targets for 2005								
		≤ 1.015	1.016 - 1.265	1.266 - 1.515	1.516 - 1.765	1.766 - 2.015	2.016 - 2.265	2.266 -
		18,9	16,2	13,2	11,9	10,8	9,8	8,7
LPG Passenger Cars - Targets for 2010								
< 702	703 - 827	828 - 1.015	1.016 - 1.265	1.266 - 1.515	1.516 - 1.765	1.766 - 2.015	2.016 - 2.265	2.266 -
15,9	14,1	13,5	12,0	9,8	7,9	6,7	5,9	4,8

FUEL CONSUMPTION - CO_2 EMISSIONS

JAPAN

2015 FUEL ECONOMY FOR ALL FUELS

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

Average

Vehicle Class	2004 Avg value - km/l	2015 Avg value - km/l	Change %
PC	13,6	16,8	23,5
Small busses	8,3	8,9	7,2
LCV	13,5	15,2	12,6

Vehicle weight (kg) - Fuel Economy (km/l)

Gasoline Passenger Cars - Targets for 2015								
≤ 600	601 - 740	741 - 855	856 - 970	971 - 1.080	1.081 - 1.195	1.195 - 1.310	1.311 - 1.420	1.421 - 1.530
22,5	21,8	21,0	20,8	20,5	18,7	17,2	15,8	14,4
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		
13,2	12,2	11,1	10,2	9,4	8,7	7,4		

Gasoline Passenger Cars - Targets for 2020							
800	910	1.020	1.130	1.250	1.360	1.470	1.590
	741	856	971	1.081	1.196	1.311	1.421
~	~	~	~	~	~	~	~
740	855	970	1.080	1.195	1.310	1.420	1.530
24,6	24,5	23,7	23,4	21,8	20,3	19,0	17,6
1.700	1.810	1.930	2.040	2.150	2.270	2.500	
1.531	1.651	1.761	1.871	1.991	2.101	2.271	
~	~	~	~	~	~	~	
1.650	1.760	1.870	1.990	2.100	2.270		
16,5	15,4	14,4	13,5	12,7	11,9	10,6	

Other requirements:

- CAFE will be introduced to encourage further FE improvement
- Test cycle: combined JC08
  (FE_JC08_total= 1 / (0,25/FE_JC08_cold + 0,75/FE_JC08_hot)
- Diesel FE = FE_JC08_total / 1,1
- LPG FE = FE_JC08_total / 0,78

FUEL CONSUMPTION - CO_2 EMISSIONS

BRAZIL

NEW BRAZILIAN AUTOMOTIVE POLICY

The program helps the conscious consumption to enable the classification of the new car compared to its emission levels of pollutants, which adds to the traditional parameters such as choice of makes and models, power consumption and fuel type. It also is a tool to stimulate the automotive sector in search of environmentally more suitable for the development of engines, vehicles and fuels.

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

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

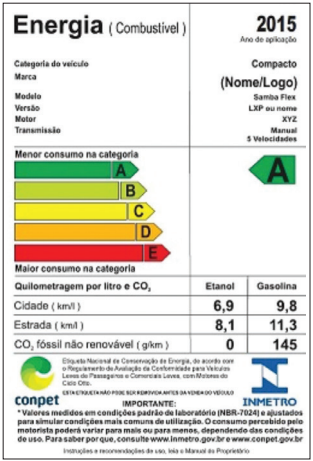
- Model level between 80% and limit = 1 star
- Model level between 60% and 80% limit = 2 stars
- Model level below the 60% threshold = 3 stars

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 the 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



FUEL CONSUMPTION - CO_2 EMISSIONS

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 Caracteristic	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

Subcompact

Energetic Consumption EC - (MJ/kg)	PBE Classification
EC ≤ 1,60	A
1,60 < EC ≤ 1,67	B
1,67 < EC ≤ 1,78	C
1,78 < EC ≤ 1,92	D
EC > 1,92	E

Medium

Energetic Consumption EC - (MJ/kg)	PBE Classification
EC ≤ 1,76	A
1,76 < EC ≤ 1,84	B
1,84 < EC ≤ 1,90	C
1,90 < EC ≤ 2,00	D
EC > 2,00	E

Compact

Energetic Consumption EC - (MJ/kg)	PBE Classification
EC ≤ 1,76	A
1,76 < EC ≤ 1,84	B
1,84 < EC ≤ 1,94	C
1,94 < EC ≤ 2,04	D
EC > 2,04	E

Large

Energetic Consumption EC - (MJ/kg)	PBE Classification
EC ≤ 1,95	A
1,95 < EC ≤ 2,04	B
2,04 < EC ≤ 2,24	C
2,24 < EC ≤ 2,53	D
EC > 2,53	E

FUEL CONSUMPTION - CO_2 EMISSIONS

BRAZIL

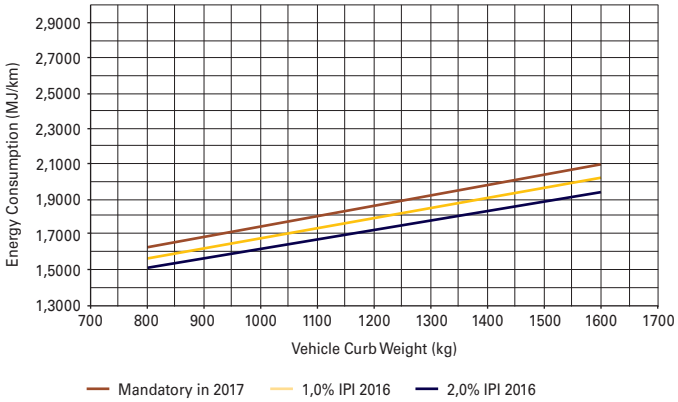
INOVAR AUTO PROGRAM

The Law 7716/2012 (April 2012) defines a program to create incentives to improve innovation in the production chain of the automotive industry. This program, called INOVAR-AUTO, defines conditions to grant a 30% reduction in the IPI to all vehicles for which most of the production steps are completed.

ENERGY EFFICIENCY REGULATION

The companies will have to commit to a 12,08% increase in energy efficiency in five years (until 01 Oct 2017).
Fuel consumption limits in MJ/km versus vehicle weight (kg).

Energy Efficiency Regulation



FUEL CONSUMPTION - CO_2 EMISSIONS

PR OF CHINA

PASSENGER CARS

China Fuel Consumption Evaluation Methods and Targets for Passenger Cars, GB 27999, L/100 km" is used to calculate the target CAFC which is the requirement for vehicle maker to limit the average fuel consumption of the VM. The VM whose CAFC above the target may be punished by the government. And it should be demonstrated for the CAFC. The government wants the average fuel consumption to be reduced to about 5L/100 km (equivalent to 120 g CO_2/km) in 2020.

The CAFC target can be calculated by $T_{CAFC} = \frac{\sum_{i=1}^{n} T_i \times V_i}{\sum_{i=1}^{n} V_i}$

Where,

i = the serial number of the vehicle type made by the VM,

Ti = the 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"

Vi = the annual quantity of the single type of vehicle I

CAFC Requirement in GB 27999		
GB 27999-2011	2012	109%
	2013	106%
	2014	103%
	2015	100%
GB 27999-2014	2016	134%
	2017	128%
	2018	120%
	2019	110%
	2020	100%

China Fuel Consumption Limits for Passenger Cars, GB 19578, L/100 km

Curb Mass (CM), kg	Stage 1: 1 Jul 2005		Stage 2: 1 Jul 2008		1 Jan 2016	
	M/T	A/T, or no less than 3 rows of seats	M/T	A/T, or no less than 3 rows of seats	M/T, and less than 3 rows of seats	A/T
CM ≤ 750	7,2	7,6	6,2	6,6	5,2	5,6
750 < CM ≤ 865	7,2	7,6	6,5	6,9	5,5	5,9
865 < CM ≤ 980	7,7	8,2	7	7,4	5,8	6,2
980 < CM ≤ 1.090	8,3	8,8	7,5	8	6,1	6,5
1.090 < CM ≤ 1.205	8,9	9,4	8,1	8,6	6,5	6,8
1.205 < CM ≤ 1.320	9,5	10,1	8,6	9,1	6,9	7,2
1.320 < CM ≤ 1.430	10,1	10,7	9,2	9,8	7,3	7,6
1.430 < CM ≤ 1.540	10,7	11,3	9,7	10,3	7,7	8
1.540 < CM ≤ 1.660	11,3	12	10,2	10,8	8,1	8,4
1.660 < CM ≤ 1.770	11,9	12,6	10,7	11,3	8,5	8,8
1.770 < CM ≤ 1.880	12,4	13,1	11,1	11,8	8,9	9,2
1.880 < CM ≤ 2.000	12,8	13,6	11,5	12,2	9,3	9,6
2.000 < CM ≤ 2.110	13,2	14	11,9	12,6	9,7	10,1
2.110 < CM ≤ 2.280	13,7	14,5	12,3	13	10,1	10,6
2.280 < CM ≤ 2.510	14,6	15,5	13,1	13,9	10,8	11,2
2.510 < CM	15,5	16,4	13,9	14,7	11,5	11,9

China Fuel Consumption Evaluation Methods and Targets for Passenger Cars, GB 27999, L/100 km				
Curb Mass (CM), kg	1 Jul 2012		1 Jul 2016	
	M/T	A/T, or no less than 3 rows of seats	Less than 3 rows of seats	No less than 3 rows of seats3
CM ≤ 750	5,2	5,6	4,3	4,5
750 < CM ≤ 865	5,5	5,9	4,3	4,5
865 < CM ≤ 980	5,8	6,2	4,3	4,5
980 < CM ≤ 1.090	6,1	6,5	4,5	4,7
1.090 < CM ≤ 1.205	6,5	6,8	4,7	4,9
1.205 < CM ≤ 1.320	6,9	7,2	4,9	5,1
1.320 < CM ≤ 1.430	7,3	7,6	5,1	5,3
1.430 < CM ≤ 1.540	7,7	8	5,3	5,5
1.540 < CM ≤ 1.660	8,1	8,4	5,5	5,7
1.660 < CM ≤ 1.770	8,5	8,8	5,7	5,9
1.770 < CM ≤ 1.880	8,9	9,2	5,9	6,1
1.880 < CM ≤ 2.000	9,3	9,6	6,2	6,4
2.000 < CM ≤ 2.110	9,7	10,1	6,4	6,6
2.110 < CM ≤ 2.280	10,1	10,6	6,6	6,8
2.280 < CM ≤ 2.510	14,6	15,5	7	7,2
2.510 < CM	15,5	16,4	7,3	7,4

LIGHT DUTY COMMERCIAL VEHICLES (GB 20997-2007)

Applicable for N1 and M2 vehicles (GVW ≤ 3.500 kg)

Implementation dates from 01 Feb 2008, Phase 2 for new certif. vehicles; 01 Jan 2009, Phase 1 for in-prod.vehicles (certif. before 01 Feb 2008); 01 Jan 2011, Phase 2 for all vehicles

Gross Vehicle Mass (M) (kg)	Engine Displacement (V) (l)	Phase 1 (l/km)	Phase 2 (l/km)
FC Limit Table 3 for category N1 Gasoline Vehicles			
M ≤ 2.000	All	8,0	7,8
2.000 < M ≤ 2.500	V ≤ 1,5	9,0	8,1
	1,5 < V ≤ 2,0	10,0	9,0
	2,0 < V ≤ 2,5	11,5	10,4
2.500 < M ≤ 3.000	V ≤ 1,5	13,5	12,5
	V ≤ 2,0	10,0	9,0
	2,0 < V ≤ 2,5	12,0	10,8
M > 3.000	V ≤ 2,5	14,0	12,6
	V ≤ 2,5	12,5	11,3
	2,5 < V ≤ 3,0	14,0	12,6
	V > 3,0	15,5	14,0
FC Limit Table 4 for category N1 Diesel Vehicles			
M ≤ 2.000	All	7,6	7,0

2.000 < M ≤ 2.500	V ≤ 2,5	8,4	8,0
	2,5 < V ≤ 3,0	9,0	8,5
	V > 3,0	10,0	9,5
2.500 < M ≤ 3.000	V ≤ 2,5	9,5	9,0
	2,5 < V ≤ 3,0	10,0	9,5
	V > 3,0	11,0	10,5
M > 3.000	V > 2,5	10,5	10,0
	2,5 < V ≤ 3,0	11,0	10,5
	3,0 < V ≤ 4,0	11,6	11,0
	V > 4,0	12,0	11,5
FC Limit Table 5 for category M2 Gasoline Vehicles (GVW ≤ 3.500 kg)			
M ≤ 3.000	V ≤ 2,0	10,7	9,7
	2,0 < V ≤ 2,5	12,2	11,0
	2,5 < V ≤ 3,0	13,5	12,2
	V > 3,0	14,5	13,1
M > 3.000	V ≤ 2,5	12,5	11,3
	2,5 < V ≤ 3,0	14,0	12,6
	V > 3,0	15,5	14,0
FC Limit Table 6 for category M2 Diesel Vehicles			
M ≤ 3.000	V ≤ 2,5	9,4	8,5
	V > 2,5	10,5	9,5
M > 3.000	V ≤ 3,0	11,5	10,5
	V > 3,0	12,5	11,5

FUEL CONSUMPTION - CO_2 EMISSIONS

SOUTH KOREA

From 2010, for gasoline & diesel engines ≤ 1.600 cc: 12,4 km/l
From 2012: ≥ 17 km/l or ≤ 140 g GHG/km fleet average
From 2016: 24,3 km/l or 97 g GHG/km fleet average
2016 10% 2017 20% 2018 30% 2019 60% 2020 100%
Government will evaluate coast down data through real road test

TAIWAN

Fuel economy standards for PC, LDT ≤ 2,5 t (km/l)

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.

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EU REFERENCE TEST FUELS

REGULATION 2008/692/EC

UNLEADED GASOLINE FUEL: PETROL (E5)

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 / E10
Octane	RON/MON	95/85
RVP	kPa	56-60 [1]
Density at 15°C	kg/m³	743-756
Distillation at 100°C	% vol	48-60
Distillation at 150°C	% vol	82-90
Final Boiling Point	°C	190-210/170-195
Aromatics	% vol	29-35/25-32
Olefins	% vol	3-13/6-13
Benzene	% vol	≤ 1
Oxygen	% mass	Ethanol only
Sulfur	mg/kg	≤ 10
Lead	mg/l	≤ 5
Phosphorus	mg/l	≤ 1,3
Ethanol	% vol	4,7-5,3/9-10

DIESEL FUEL: DIESEL (B5)

Parameter	Unit	Limits
Cetane		52-54
Density at 15°C	kg/m³	833-837
Distillation T50	°C	≥ 245
Distillation T95	°C	345-350
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
Sulfur	mg/kg	≤ 10
FAME	% vol	4,5-5,5
Oxydation stability	mg/ml	≤ 0,025
Oxydation stability @ 110°C	hr	≥ 20

[1] Different values for cold temperature test fuel: RVP: 56-95 KPa

US REFERENCE TEST FUELS

CERTIFICATION UNLEADED GASOLINE FUEL

Parameter	Unit	EPA			CARB Phase 3
		Ambient	Cold CO		
			low octane	high octane	
Octane	(R+M)/2	93	87,8±3	92,3±0,5	91
RVP [1]	psi (kPa)	8,0-9,2 (55,2-63,4)	11,5±3	11,5±3	6,7-7,0 (46,8-48,3)
RVP Evap	psi (kPa)	8,7-9,2 (60-63,4)			7 (48,3)
T10	°F	120-135	98-118	105-125	130-150
T50	°F	200-230	179-214	195-225	200-210
T90	°F	300-325	316-346	316-346	290-300
FBP	°F	415	413	413	390
Aromatics	% vol	35	26,4±4	32±4	22-25
Olefins	% vol	10	12,5±5	10±5	4-6
Benzene	% vol				0,8-1

Parameter	Unit	EPA			CARB Phase 3
		Ambient	Cold CO		
			low octane	high octane	
Sulfur	ppm	15-80 [2]	15-80 [2]	15-80 [2]	30-40
Lead	g/gal (g/l)	0,05 (0,013)	0,01 (0,0026)	0,01 (0,0026)	0,01
Phosphorus	g/gal (g/l)	0,005 (0,0013)	0,005 (0,0013)	0,005 (0,0013)	0,005

RVP - Reid Vapor Pressure

[1] RVP for altitude testing: 7,6-8,0 psi or 52-55 kPa

[2] The road fuel will be 30 ppm avg. 80 ppm max.

Note: CARB Phase 3 fuel may use Ethanol as oxygenate.
Benzene limit for road fuel: 0,62% by vol. on an annual refinery average.
E15 fuel being proposed for pump gasoline.

US REFERENCE TEST FUELS

CERTIFICATION DIESEL FUEL

Fuel Property	Unit	Federal Specifications		California Specifications	Test [3]
		1-D [2]	2-D		
Cetane Number (natural)		40-54	40-50	47-55	D-613
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 (wt.)	7-15	7-15	7-15	D-2622; 13 CCR section 2282(g) [3]
Nitrogen Content (max.)	ppm (wt.)			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	% (wt.)			1,4 (max.)	
Flashpoint (min.)	°F (°C)	120 (49)	130 (54)	130 (54)	D-93
Viscosity @ 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, naphthenes, 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 Title 13, CCR procedures.

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CONVENTIONAL US / EU TEST PROCEDURES

SEQUENCE FOR EVAPORATIVE EMISSIONS TESTING

Preconditioning	Fill to 40% with test fuel (US: 8,7-9,2 RVP, EU: 8,1-9,3 RVP) US: EPA II (18 cycles) EU: Purge canister by driving or air purge 2x diurnal heat build, (heat fuel 16-30°C), 1 ECE + 2 EUDC cycles
Soak	12-36 hr (68-86°F / 20-30°C ambient)
Fuel drain/fill	Drain tank, Fill 40 ± 2% with test fuel (US: fuel 45-60°F / EU: fuel 10-14°C)
Diurnal Test (SHED)	Heat fuel tank for 1 hr (US: 60-84°F / EU: from 16-30°C)
Exhaust Test	US: EPA III (Emissions measured for TA) EU: ECE + EUDC cycle (Emissions not measured for TA)
Hot Soak Test	US/EU: 1 hr at 68-86°F / 23-31°C ambient
Emissions standard: Diurnal test + Hot Soak test: 2 g	
Implementation	EU: EC 93, EC 96

Regulation EC715/2007. Regulation EC692/2008 Annex VI.
UN/ECE Regulation No. 83 Annex 7

Fuel drain/fill	Fill to 40% with test fuel
Canister Preconditioning	Canister loading: Repeated diurnal heat builds or Butane/N_2 loading to 2 g 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 hr (20-30°C ambient)
Exhaust Test	ECE + EUDC at 20-30°C
Evap Cond. Drive	Urban cycle max. 2 min later
Hot Soak Test	1 hr at 23-31°C ambient
Soak	6-36 hr (min 6 h at 20 ± 2°C ambient)
Real Time Diurnal Test	1 heat build in 24 hr in VT SHED Cycle from 20-35°C, $\Delta T = 15$ K
Emissions standard: Diurnal test + Hot Soak test: 2 g	
Implementation	As part of Euro 3-4, TA: 01 Jan 2000

Euro 6c/6d emission regulation is not finalized yet. More restrictive purge; multi-diurnal test (48 hr) and durability requirements (ethanol fuels) are expected.
OBD requirements and test procedures under development. Euro 6c/6d implementation (see page 11)
China V Conformity of production for canister: measured BWC & Volume no less than 0,9 of declared value: Conformity of in-use < 2 g/day required for usefull life

ENHANCED EVAPORATIVE EMISSIONS

US FEDERAL / CALIFORNIA REQUIREMENTS

Temperature	Test sequence	
	3-day diurnal	Supplemental 2-day
68-86°F (20-30°C)	Fuel drain / fill	Fuel drain / fill
	6 hr minimum soak	6 hr minimum soak
	Preconditioning: 1 EPA II. Fuel drain/fill. 12-36 hr soak → Canister purge: 300 BV at 0,8 cfm with 25-75 gr/lb dry air → Canister load: 1,5 x WC at 15 g butane/hr with 50/50 butane/N_2 mix	Preconditioning: 1 EPA II. Fuel drain/fill. 12-36 hr soak → Canister load: Load to 2 g breakthrough at 40 g butane/hr with 50/50 butane/N_2 mix
	Exhaust test: EPA III	Exhaust test: EPA III
EPA: 90-100°F CARB: 100-110°F	1-6 hr soak **Running loss test** EPA II, 2x NYCC, EPA II	Not required

Temperature	Test sequence	
	3-day diurnal	Supplemental 2-day
EPA: 90-100°F CARB: 100-110°F	**1 hr Hot soak Test (EPA 95 / CARB 105°F)**	**1 hr Hot soak Test (68-86°F)**
	Stabilize Temp: 6-36 hr (EPA 72 / CARB 65°F)	Stabilize Temp: 6-36 hr (EPA 72 / CARB 65°F)
	Diurnal emission test 3 heat builds in 72 hr EPA: Cycle 72-96°F CARB: Cycle 65-105°F	**Diurnal Emission Test** 2 heat builds in 48 hr EPA: Cycle 72-96°F CARB: Cycle 65-105°F
	Running Loss: 0,05 g/mi	-
	Standard for Hot Soak + Highest Diurnal (g)	
EPA/CARB LEV I	2,0 g/test	2,5 g/test
CARB LEV II	0,50 g/test	0,65 g/test
EPA Tier II	0,95 g/test	1,2 g/test

Note: Vehicle certification requires the 3-day diurnal, in-use vehicles the supplemental 2-day diurnal 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 84). For hybrid vehicles, battery state-of-charge setting prior to the exhaust test shall be at the level minimizing operation of engine.

ENHANCED EVAPORATIVE EMISSIONS

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

New EPA Evaporative Emission 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 in 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 yrs
- 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) & 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 regulated for the first time

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

Further EPA Tier III Requirements (29 Mar 2013)

Tier III EVAP begins in 2018, same phase-in %'s as CARB LEV III
Harmonization 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
- Requirement 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-evaporative technology to remaining vehicle classes
- Two options for complying with total hydrocarbon evaporative emissions from 2015 and subsequent model motor vehicles:

	Vehicle Type	Running Loss (g/mile)	Three-day Diurnal + Hot Soak and Two-Day Diurnal + Hot Soak	
			Whole Vehicle (g/test)	Fuel Only (g/test)
Option 1	Passenger Cars	0,05	0,350	0,0
	LD Trucks 6.000 lbs GVWR and under	0,05	0,500	0,0
	LD Trucks 6.000-8.500 lbs GVWR	0,05	0,750	0,0
	MD Passenger Vehicles	0,05	0,750	0,0
	MD Vehicles 8.501-14.000 lbs GVWR	0,05	0,750	0,0
	HD Vehicles over 14.000 lbs GVWR	0,05	0,750	0,0

	Vehicle Type	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 GVWR and under and 0-3.750 lbs LVW	0,05	0,300	0,020
	LD Trucks 6.000 lbs GVWR and under and 3.751-5.750 lbs LVW	0,05	0,400	0,020
	LD Trucks 6.000-8.500 lbs GVWR and MD Passenger Vehicles	0,05	0,500	0,020
	MD Vehicles 8.501-14.000 lbs GVWR and HD over 14.000 lbs GVWR	0,05	0,600	0,030

- Implementation schedule: 2015-2017 min. average of previous 3 models per year PZEVs, 2018-2019 min. 60%, 2020-2021 min. 80%, 2022 and subsequent 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 size 0,01-0,02 in. to complete the current 2-day or 3-day diurnal test procedure sequence)
- The “usefull live” shall be 15 years or 150.000 mi, which ever occurs first

ON-BOARD REFUELLING VAPOUR RECOVERY

- Applicable in all US Federal States. CARB adopted EPA regulation Phase-in with 40/80/100% over 3 years.
  Passenger cars: MY 1998-2000
  LDT ≤ 6.000 lbs GVW: MY 2001-2003
  LDT > 6.000 lbs GVW: MY 2004-2006
  Small volume manufacturers for passenger cars have to comply for 100% in MY 2000
- No changes to ORVR procedures for CARB LEV II and EPA Tier II
- Measurement of emissions that escape from the vehicle during a refuelling emissions event. Stand-alone test in addition to enhanced EVAP tests
  Fuel used: US Federal Cert. fuel: 8,7-9,2 RVP

CARB's LEV III Amendment

California certification fuel E10 (7 psi RVP) may be alternatively used for 2015 and subsequent model vehicles. 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)

New China V/VI Draft Under Discussion

Type VII test ORVR emission requirement < 0,05 g/l based on CARB test procedure

Vehicle Preconditioning	Fuel drain + fill to 40% 6 hr min Soak at 68-86°F (20-30°C) 1x EPA II Preconditioning Drive
Canister Preconditioning	→ Fuel drain + fill to 40% → 12-36 hr Soak. Load canister with HC vapours until 2 g breakthrough at 40 g/h 50% butane/N_2 → Exhaust test: EPA III (record emissions) 0-1 hr Soak at 68-86°F → Canister purge drive at 68-86°F: EPA II, 2x NYCC, EPA II
Refuelling Event	→ Disconnect canister(s) → Fuel drain + fill to 10% → 6-24 hr 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 refuelling until fuel dispensed is ≥ 85%. Administrator may use 4 gallon/min rate (15 l/min). Dispense fuel temp: 67°F ±1,5°F (19°C)
HC standard: 0,20 g/gallon (0,053 g/l)	

ON-BOARD REFUELLING VAPOUR RECOVERY

EPA FUEL DISPENSING SPITBACK TEST

⇒ Applicable in all US Federal States for vehicles ≤ 14.000 GVW. Spitback phase-in same as enhanced EVAP (100% phase-in by 1999)

⇒ Measurement of liquid fuel spitback from the fuel filler inlet during a refuelling 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; the canister should be loaded using fuel-tank-refill method described under “Refuelling Event” section and purged while performing vehicle driving, using either the chassis dynamometer procedure or the test track procedure, as described in subparagraphs (d)(1) and (d)(2) of 40 CFR 86.153-98. Vehicle drivedown shall consume 85% or less of the nominal fuel tank capacity.

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 [cm³]	Euro Level	Mass of [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 No2	2006
		V_{max} ≥ 130 km/h	3	2.620	330	220	-	GTR No2	2006

Vehicle Category	Vehicle Category Name	Classification [cm³]	Euro Level	Mass of [mg/km]				Test Cycle	Applicable as of
				CO	HC	NOx	HC+NOx		
	Positive Ignition								
L2e [7]	Three-wheel mopeds	< 50	2+3						
L5e	Tricycles	≥ 50	2	7.000	1.500	400	-	L2+L6: ECE R47 L5+L7 UDC	2003
L6e [8]	Light quadricycles	< 50	2+3						
L7e	Heavy quadricycles	≥ 50	2						
	Compression Ignition								
L2e	Three-wheel mopeds	< 50	2						
L5e	Tricycles	≥ 50	2	2.000	1.000	650	-	L2+L6: ECE R47 L5+L7 UDC+EUDC	2003
L6e	Light quadricycles	< 50	2						
L7e	Heavy quadricycles	≥ 50	2						

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 (categories 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 starts at t = 0
6) Emissions measured from all modes — sampling starts at t = 0
7) 8) 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) No134/2014 [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 4 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	

Test Type	Description	Requirements: limit values	
		Euro 4 step [4]	Euro 4 step [5]
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 environmental 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 step effect study shall be presented to the Council and European Parliament by 31 Dec 16, elements: confirmation Euro 5 step, in-use conformity testing requirements, off-cycle emission requirements, particulate number emission limit for certain (sub-) categories.

[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) pending Euro 5 step effect study in accordance with Article 23(4) and (5) of Regulation (EU) No 168/2013
[6] OJ L 141, 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)

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	THC	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

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	PI/PI/Hybrid	1.000	100	68	60	4,5	Revised WMTC
	vehicles	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 the outcome of the Euro 5 step effect study

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, w/o side-car	PI	2.000	SHED [2]
L5e-A	Tricycle			
L6e-A	Light on-road quad			
L7e-A	Heavy on-road quad			

[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

EURO 5 STEP

Veh. Cat. [21]	Vehicle Category Name	Propulsion Class	Permeation Test [22]		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 quadri-mobile		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 quadri-mobile		1.500	15.000	1.500

[1] For (sub-)Cat. L1e, L2e, L5e-B, L6e-B, L7e-B and L7e-C, applicable test type to be determined pending the Euro 5 effect study. Pending the results of the study the vehicle subcategory will either be made subject to permeation testing or SHED testing, the respective other test type shall not apply

[2] Permeation test procedure set out in appendix 2 to Annex V of Reg. (EU) No 134.2014

EUROPEAN UNION

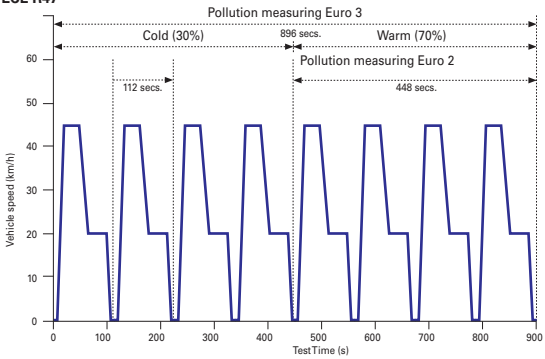
TEST TYPE V, POLLUTION OF EMISSION CONTROL DEVICES, MINIMUM DISTANCE ACCUMULATION [1)]

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, w/o 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, w/o 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 of Reg. (EU) No 168/2013

WMTC

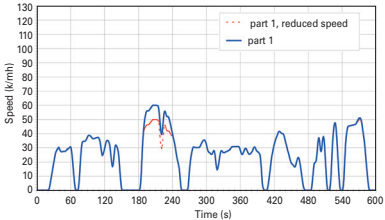
ECE R47 [2)]

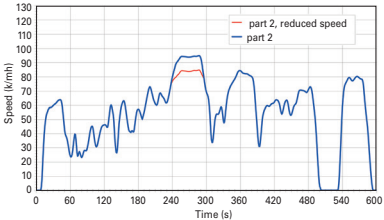


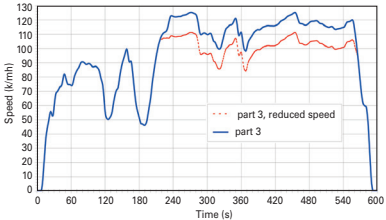
[2)] ECE R47 test cycle set out in Dir. 2013/60/EU and 97/24/EC (until 31 Dec 17) and set out in Reg. (EU) No 134/2014 (voluntary after 11 Sep 14, obligatory after 01 Jan 18). NB the EU has not acceded to UN Reg. No 47 and which is therefore not accepted for whole vehicle type-approval of mopeds. Pending the Euro 5 step effect study 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/h
	2-2	115 km/h ≤ V_{max} < 130 km/h
	3-1	130 ≤ 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
06+	I	50-169	1,0	12		
06+	II	170-279	1,0	12		
06-09	III	≥ 280	1,0	12	1,4	5,0
10+	III	≥ 280		12	0,8	5,0

Regulations are fuel neutral.
Class I: 0 to 169 cc Class II: 170 to 279 cc Class III: ≥ 280 cc
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.

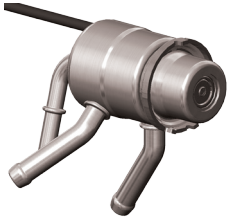
CALIFORNIA MOTORCYCLE LIMITS

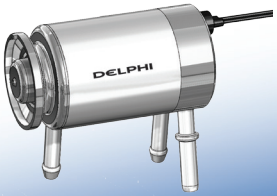
California Motorcycle Standards (g/km)

Year	Class	Disp.	HC		CO	HC+NOx	
			corp. ave	max		corp. ave	max
88-03	I & II	50-279	1,0	2,5	12		
88-03	IIIa	280-699	1,0	2,5	12		
	IIIb	700+	1,4	2,5	12		
04-07	III	≥ 280			12	1,4	2,5
08+	III	≥ 280			12	0,8	2,5

When it comes to SCR, Delphi has solutions not only for today but tomorrow as well.

Delphi has developed a robust, low pressure doser for today's SCR installations. The doser is based on Delphi port fuel injection technology which injects the aqueous urea solution through spray jets at pressures up to 8 bar. For tomorrow, Delphi is developing an innovative high pressure doser capable of injecting at up to 75 bar, enabling further NOx reduction even under cold exhaust conditions.





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OTHER AREAS OF THE WORLD

Brazil

Phase-in requir: PROMOT 4 / WMTC cycle - Idle HC & CO - 2014: 400 ppm of HC revised, and 2% of CO revised - Fixed DF 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)	Jan 2003	Jul 2003 (MCs)
			Jan 2004 (mopeds)
Stage II	GB18176-2002 (mopeds)	Jan 2004 (MCs)	Jan 2005 (MCs)
		Jan 2005 (mopeds)	Jan 2006 (mopeds)
Stage III	GB 14622-2007 (MCs) GB18176-2007 (mopeds)	Jul 2008	Jul 2009 [1)]

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

China (contd.)	Application Date	Description	Engine Size	HC	NOx	HC + NOx	CO	Driving Cycle	Cold start	Durability
	2008	2 W 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	Yes	18.000 km
			≥ 150 CC	0,3	0,15	-	2	ECE R40+EUDC		30.000 km
		3 W with Two-Stroke Engine	< 50 CC (moped)	-	-	1,2	3,5	ECE R47	Yes	10.000 km
			≥ 50 CC	1	0,25	-	4	ECE R40	Yes	12.000 km
										18.000 km
										30.000 km
		3 W with Four-Stroke Engine	< 50 CC (moped)	-	-	1,2	3,5	ECE R47	Yes	10.000 km
			≥ 50 CC	1	0,25	-	4	ECE R40	Yes	12.000 km
										18.000 km
										30.000 km

India	Standard	Description	Class	Definition	Test cycle
	Bharat IV	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 Sep 2013. Standards for motorcycles / larger mopeds use WMTC test cycle; standards for smaller mopeds continue to be based upon ISDO 6460 test cycle. New standards, to include OBD and evap emissions, are proposed for beg. 2017, will be based upon Euro 4 limits (with some variations) and will use WMTC procedures and vehicle classifications.								
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 2 W and Euro 2 for 3 W, as specified in European Directive 97/24/EC.								
South Korea	**Standard**	**Application**	**Description**	**Test Cycle**	**CO [g/km]**	**HC [g/km]**	**NOx [g/km]**	**HC+NOx [g/km]**	**Evap [g/test]**
	Euro 2	Jan 2008	All 3 W	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	2	0,3	0,15		
			2W < 45 km/hr	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	0,7	-	
			2W > 50 CC PI & V_{max} < 130 km/h		1,14	0,38	0,7		2,0
			2W > 50 CC PI & V_{max} ≥ 130 km/h		1,14	0,17	0,9		2,0
	Euro 5	Jan 2020		WMTC	**CO [g/km]**	**THC**	**NMHC**	**NOx**	**Evap**
					1,0	0,1	0,66	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.								

GLOSSARY

AMA	Accelerated Mileage Accumulation
ASM	Acceleration Simulation Mode
BV	Bed Volume
CAFE	Corporate Average Fuel Economy (US)
CI	Compression Ignition
CF	Compliance Factors
COP	Conformity of Production
CWF	Carbon Weight Fraction (US)
DF	Deterioration Factor
DI	Direct Injection
EOBD	European Union On-board Diagnostic
EUDC	Extra Urban Driving Cycle
Evap	Evaporative Emissions
FAME	Fatty Acid Methyl Esters
FC	Fuel Consumption (EU)
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
IBS	Pounds (1 lb = 454 g)
IDI	Indirect Diesel Injection
IUPR	In-Use Performance Ratio
LCV	Light Commercial Vehicle
LDT	Light Duty Trucks
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
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 Vapour Recovery
PEMS	Portable Emission Measurement System
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)
SI	Spark Ignition
SHED	Sealed House for Evaporation Determination
TA	Type Approval
TF	Transfer Function
UDDS	Urban Dynamometer Driving Schedule
VT SHED	Variable Temperature SHED
WC	Working Cycle
WLTC	Worldwide Light duty Test Cycle
WLTP	Worldwide Light duty Test Procedure

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 expert committee to the EU commission

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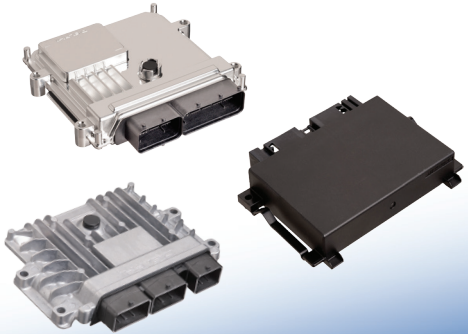

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