Worldwide Emissions Standards

Heavy Duty & Off-Road Vehicles

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2009

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ECE

ECE regulations are similar to EU directives. A base regulation is updated in a consecutive series of amendments. Dates of implementation differ from country, depending on the approval status of the respective amendment in that country.

ECE – R49/00-02 (applied to C.I. engines only)

TEST	UNIT	CO		HC		NOx		PM	
		TA	COP	TA	COP	TA	COP	TA	COP
R49	g/kWh	14	-	3.5	-	18	-	-	-
R49-1	g/kWh	11.2	12.3	2.4	2.6	14.4	15.8	-	-
R49-2: 2 stages									
Stage I	g/kWh	4.5	4.9	1.1	1.23	8.0	9.0	0.36	0.40
Stage II		4.0	4.0 [1)]	1.1	1.1 [1)]	7.0	7.0 [1)]	0.15	0.15 [1)]

Stage I: applicable from 01 Jul. 92

Stage II: applicable from 01 Oct. 95

[1)] Stage II COP limits apply from 01 Oct. 96

ECE – R49/03 content equivalent to 88/77/EEC, amended by 99/96/EC, (EURO III and IV standards)

= approval of C.I. and NG and of P.I. fuelled with LPG engines

= application for approval of a vehicle by its approved engine or engine family

Test cycles (See pages 16 -17)

Diesel Euro III: ESC/ELR. ETC can be requested.
Euro IV: ESC, ELR and ETC.

Gas engines, ETC test.

Implementation dates:

Euro III: 2000; Euro IV: 01 Oct. 05

ECE – R49/04 – Amendment 01-05 (equivalent to Dir 2005/55/EC and Dir 2005/78/EC)

= certification of gas engines with new testing validity criteria to cover their different dynamic response to that of diesel engines.

Test cycle: Euro V: ESC, ELR and ETC

Implementation dates: Euro V: 01 Oct 08

Emission limits: see page 10

WHDC GTR n°4 has been adopted as annex 10 to ECE Reg 49 (see p. 4)

WWH-OBD GTR n°5 has been adopted as annex 11 to ECE Reg 49 (see p. 43)

Proposed amendment: PMP (Particle Measurement Program)
Discussion document: Particle count should be determined by integration and particle emissions expressed as Number/kWh.

ECE

ECE - R24/03

This Reg applies to the emission of visible exhaust pollutants from C.I. engines fitted to road vehicles.

Two tests are required:

- Speed Stabilized under full load

6 measurements shall be made at engine speeds spaced out uniformly between that corresponding to maximum power and the higher of the following two engine speeds: 45% of the engine speed corresponding to maximum power; and 1000 rpm. For each measuring point, the smoke measured should not exceed the limit values (SL) specified in the directive, which are a function of the air flow rate. The value selected will be the measured (SM) nearest the relevant limit value.

- Free acceleration:

With warm engine from idle to maximum speed giving an average (XM) of 4 consecutive non-dispersed values.

Calculated according both tests:

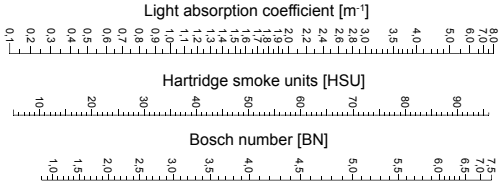
XL1 = (SL/SM)*XM and XL2 = XM + 0.5

The lowest numerical XL value will be marked on the vehicle and will be used as a reference for checking production which should not be greater than this value more than 0.5 m^{-1}.

Additional requirement for turbo engines:

XM ≤ SL (corresponding to max SM) + 0.5 m^{-1}

- Conversion of Diesel Smoke values



ECE

Worldwide Harmonised Heavy Duty Emissions Certification Procedure

Establishment of a harmonised Global Technical Regulation (GTR) covering the TA procedure for HD engine exhaust emissions, adopted on Nov 15, 2006

Application: C.I. engines and P.I. engines fuelled w/ NG and LPG, design speed > 25 km/h and max mass > 3,5 tons.

Two representative test cycles have been created covering typical driving conditions in the European Union, the USA, Japan and Australia:
- one transient test cycle (WHTC)
- one steady state test cycle (WHSC)

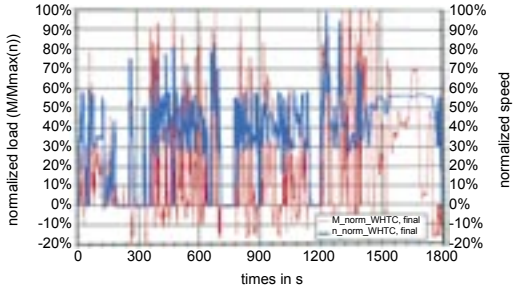
The GTR does not contain emission limit values

Exhaust Emissions to be measured: CO, HC, NMHC, NOx, PM, CO_2, expressed in g/kWh.

If GTR applied in a national legislation, the limit values should represent at least the same level of severity as its existing regulations.

WHTC

It is a second by second sequence of normalized speed and torque values.



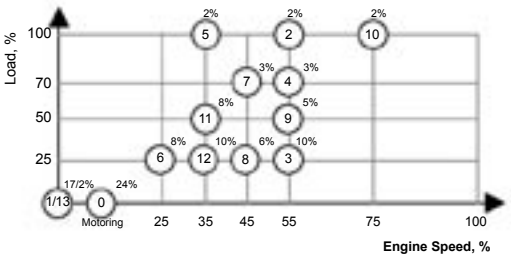
ECE

WHSC

It consists of a number of speed and power modes which cover the typical operating range of HD.

The weighting factors (WF) are given for reference only.

Idle mode is separated in 2 modes, mode 1 at the beginning and mode 13 at the end of the test cycle.

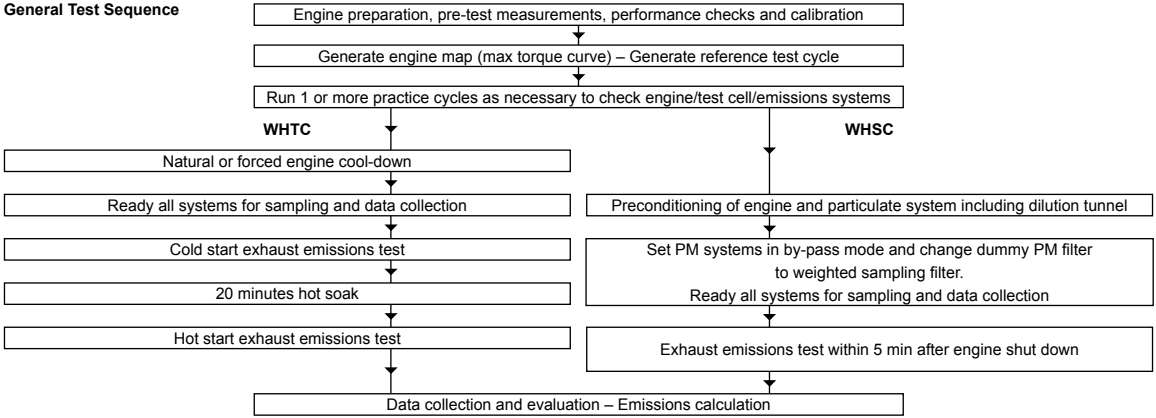


Mode	Speed [%]	Load	WF [1]	Mode length [s] Incl. 20 s ramp
0	Motoring	-	24%	-
1	0	0	17%/2	210
2	55	100	2%	50
3	55	25	10%	250
4	55	70	3%	75
5	35	100	2%	50
6	25	25	8%	200
7	45	70	3%	75
8	45	25	6%	150
9	55	50	5%	125
10	75	100	2%	50
11	35	50	8%	200
12	35	25	10%	250
13	0	0	17%/2	210
Sum			100%	1895

[1] WF = Weighting Factor

ECE - WWHD

General Test Sequence



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VEHICLE CATEGORIES Dir 70/156/EEC as amended by Dir 2001/116/EEC

GVW = Gross Vehicle Weight

Category	Description	Sub-category	Number of Persons	Mass Limit	
M	Transportation of Passengers Min. 4 wheels	M1	Up to 9 Persons	GVW ≤ 3,500 kg [1]	
		M2	Over 9 Persons	GVW ≤ 5,000 kg	
		M3		GVW > 5,000 kg	
N	Transportation of Goods Min. 4 wheels	N_1 Cl 1	N.A.	Max GVW ≤ 3,500 kg	RM ≤ 1,305 kg
		N_1 Cl 2			1,305 kg < RM ≤ 1,760 kg
		N_1 Cl 3			1,760 kg < RM ≤ 3,500 kg
		N_2		3,500 kg < GVW ≤ 12,000 kg	
		N_3		12,000 kg < GVW	

[1] Until EU4: Two subgroups: M1 with GVW ≤ 2,500 kg and M1 with 2500 kg < GVW ≤ 3,500 kg

EURO I - Dir 88/77/EEC amended by Dir 91/542/EEC

Exhaust emissions of compression ignition engines for vehicles > 25 km/h

Test Cycle	Emissions TA (1992) – FR (1993)	Unit	Engine Power (kW)	
			P ≤ 85 [1]	P > 85 [1]
ECE 49	CO	g/kWh	4.5 (4.9)	4.5 (4.9)
	HC		1.1 (1.23)	1.1 (1.23)
	NOx		8.0 (9.0)	8.0 (9.0)
	PM		0.612 (0.68)	0.36 (0.40)

[1] In brackets: COP values

EURO II - Dir 88/77/EEC as amended by Dir 91/542/EEC and Dir 96/1/EEC

Test Cycle	Emissions	Unit	EURO II - TA – FR [2] 01 Oct. 95 – 01 Oct. 96
ECE R49-02	CO	g/kWh	4.0
	HC		1.1
	NOx		7.0
	PM		0.15 [1]

[1] 0.25 g/kWh for engines with a cylinder swept volume < 0.7 liters and rated power speed > 3000 rpm and engine power < 85kW until 30 Sep 97 for TA and 30 Sep 98 for FR

[2] COP Limits = TA limits

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Euro III - Dir 88/77/EC as amended by Dir 1999/96/EC and Dir 2001/27/EC

- Diesel engines are tested on ESC and ELR cycles (see pages 16-17). NOx can be tested on ETC cycle (6.5 g/kWh) if required by TA authority
- Diesel engines fitted with aftertreatment devices (PM filters, De-NOx) are tested on ESC, ELR and ETC cycles.
- Gas engines are tested only on ETC cycle

EEV = "Enhanced Environmentally Friendly Vehicle"
= Type of vehicle propelled by an engine complying with the permissive emission target values shown in the EEV columns

Specific requirements for diesel from EURO III

- NOx measured at the random check points within the control area of the ESC test must not exceed by more than 10% the values interpolated from the adjacent test modes.
- Smoke on the random test speed of ELR must not exceed the highest smoke value of the 2 adjacent test speeds by more than 20% or by more than 5% of the limit value
- Defeat devices and irrational emission control strategies are prohibited from EURO III

Limit values – EURO III

Emissions TA: 10/2000 - FR: 10/2001	Unit	Euro III		Euro III - EEV	
		ESC/ELR	ETC	ESC/ELR	ETC
		Diesel only	Diesel / Gas	Diesel only	Diesel / Gas
CO	g/kWh	2.1	5.45	1.5	3.0
HC		0.66	-	0.25	-
NMHC		-	0.78	-	0.40
CH_4 [2]		-	1.6	-	0.65
NOx		5.0	5.0	2.0	2.0
PM		0.1/0.13 [1]	0.16/0.21 [1] [3]	0.02	0.02 [3]
Smoke	m^{-1}	0.8	-	0.15	-

[1] For engines having a swept volume of less than 0.75 dm^3 per cylinder and a rated power speed of more than 3000 min^{-1}

[2] For natural gas engines only

[3] Not applicable for gas engines – EURO III stage

EUROPEAN UNION

EURO IV - Dir 88/77/EC as amended by Dir 1999/96/EC, Dir 2005/55/EC Dir 2005/78/EC and Dir 2006/51/EC

- Diesel engines are tested on ESC, ELR and ETC cycles if required
- Gas engine are tested on ETC cycle

Emissions TA: Oct. 05 - FR: Oct. 06	Unit	EURO IV		EURO IV - EEV	
		ESC/ELR Diesel only	ETC Diesel & Gas	ESC/ELR Diesel only	ETC Diesel & Gas
CO	g/kWh	1.5	4.0	1.5	3.0
HC		0.46	-	0.25	-
NMHC		-	0.55	-	0.40
CH_4 [1]		-	1.1	-	0.65
NOx		3.5	3.5	2.0	2.0
PM		0.02	0.03 [2]	0.02	0.02 [2]
Smoke	m^{-1}	0.5	-	0.15	-

[1] For natural gas engines only

[2] Not applicable for gas fuelled engines – EURO IV stage

NOx screening – "Cycle beating"

- Cycle beating appeared from EURO III due to the use of smart electronics: Injection timing advance during transient operation (fuel consumption reduction) Retarded timings retaining during steady states (NOx reduction).
- Dir 2001/27/EC, amendment to Dir 88/77/EEC: prescriptions to prevent the use of defeat devices and/or irrational emissions control strategies.
  A NOx screening on the ETC cycle may be required by TA authority.
  ETC NOx level must not exceed ESC standards by more than 10%.
- Dir 2001/27/EC allows manufacturers to provide TA authority with the results of a NOx screening in addition to a written statement that neither defeat device nor irrational control strategy is used.
- Proposal: NOx emissions from the ETC test must not exceed the ESC standards under any operating conditions.

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Euro V – (Dir 88/77/EC as amended by Dir 2001/27/EC)
Replaced by Dir 2005/55/EC and Dir 2005/78/EC amended by Dir 2006/51/EC and Dir 2008/74/EC
For TA and for EEV's, the emissions have to be determined on the ETC and the ESC / ELR tests.

Emissions TA: 01 Oct. 08 - FR: 01 Oct. 09	Unit	Euro V		Euro V - EEV	
		ESC/ELR Diesel Only	ETC Diesel & gas	ESC/ELR Diesel Only	ETC Diesel & gas
CO	g/kwh	1.5	4.0	1.5	3.0
HC		0.46	-	0.25	-
NMHC		-	0.55	-	0.40
CH_4 [1]		-	1.1	-	0.65
NOx		2.0	2.0	2.0	2.0
PM		0.02	0.03 [2]	0.02	0.02 [2]
Smoke	m^{-1}	0.5	-	0.15	-

[1] For natural gas engines only

[2] Not applicable for gas fuelled engines for EURO V stage

Dir 2008/74/EC reflects the change of vehicle scope due to the Euro 5 & 6 regulations for passenger cars and light duty trucks.
It includes test procedures for HD and vehicles with gasoline engines.
It applies to vehicles with a reference mass > 2.610 kg.

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Euro VI regulation proposal: Split level approach:

- Co-decision regulation: adoption process on going
  proposal adopted by EU Parliament on 16 Dec 08
  includes general provisions
- Comitology regulation: draft laid down in February 2009
  includes technical requirements
  to be adopted by 01 Apr 2010

Scope: M_1, M_2, N_1 and N_2 with a RM > 2.610 kg
All M_3, N_3

Application dates:

TA: 31 Dec 2012 FR: 31 Dec 2013

Durability – Conformity of in-service vehicles or engines

- 160.000 km or 5 years
  M_1, N_1 and M_2
- 300.000 km or 6 years
  N_2, N_3 with max technically permissible mass ≤ 16 tons
  M_3, Class I, II and Class A, Class B with max technically permissible mass ≤ 7.5 tons
- 700.000 km or 7 years
  N_3 with max technically permissible mass > 16 tons
  M_3 Class III and Class B with max technically permissible mass > 7.5 tons

Procedures provisions to be defined in comitology regulation for:

- Test cycles, off cycle emissions, PN, emissions at idling speed, smoke opacity
- If appropriate, introduction of NO_2 emission limit
- Correct functioning and regeneration of pollution control devices
- Crankcase emissions
- OBD systems and in-service performance of pollution control devices
- Durability
- PEMS to verify in-use emissions
- CO_2 and fuel consumption
- Measurement of engine power
- Reference fuels
- Specific provisions to ensure correct operation of NO_x control measures
- Harmonization of national legislations on retrofitting

Unrestricted and standardized access to OBD and vehicle repair and maintenance information to independent operators

Financial incentives will be allowed until 31 Dec 2013 for:

- introduction of new vehicle in advance of Euro VI
- retrofitting of vehicles to Euro VI emission limit values
- scrapping vehicles which do not comply with Euro VI

PMP program:

PN emission limit and test procedure will be defined after completion of PMP UNECE program

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Euro VI proposed emission limits

	CO (mg/kWh)	THC (mg/kWh)	NMHC (mg/kWh)	CH_4 (mg/kWh)	NO_x[3] (mg/kWh)	NH_3 (ppm)	PM mass (mg/kWh)	PN number[2] (#/kWh)
ESC (CI)	1500	130	-	-	400	10	10	
ETC (CI)	4000	160	-	-	400	10	10	
ETC (SI)	4000	-	160	500	400	10	10	
WHSC[1]								
WHTC[1]								

[1] Limit values to be established at a later stage, when correlation factors to current ESC and ETC are established

Proposed correlation factors (TNO report - 01 Dec 2008)

	NOx	CO	HC	PM
WHTC Vs ETC	1.10	1.00	1.00	1.00
WHSC Vs ESC	1.00	1.00	1.00	1.00

[2] To be defined at a later stage [3] Admissible NO_2 in the NO_x limit value may be defined at a later stage

Subjects to further review:

- Tests, procedures, requirements and tests cycles in order to reflect real driving conditions
- If need new pollutants to regulate

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Delphi's revolutionary family of injectors and pumps precisely shapes injection events to enable fuel economy, increased performance and substantially reduced emissions.

Plus their common-package approach helps prevent the need for engine redesigns.

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Durability of emission control systems

Vehicles and engines have to confirm the correct operation of the emission control devices during the normal life of the vehicle or engine

- from 01 October 2005 for new type approvals
- from 01 October 2006 for all type approvals

Vehicle Category	Useful Life
N1 – M2	100,000 km or 5 years
N2, N3 ≤ 16 tons – M3 ≤ 7.5 tons	200,000 km or 6 years
N3 > 16 tons – M3 > 7.5 tons	500,000 km or 7 years

Deterioration factors

Manufacturers can choose to apply DF's foreseen into the directive or the DF's developed over a specific service accumulation schedule

1) DF's based on service accumulation schedule

DF's are developed from the selected engines based on a distance and service accumulation procedures that includes periodic testing for gaseous and PM emissions over the ESC and ETC tests.

Vehicle Category	Minimum service accumulation period
N1	100,000 km
N2	125,000 km
N3 w/ permissible mass ≤ 16 tons	125,000 km
N3 w/ permissible mass > 16 tons	167,000 km
M2	100,000 km
M3 w/ permissible mass ≤ 7.5 tons	125,000 km
M3 w/ permissible mass > 7.5 tons	167,000 km

2) Alternative: DF's defined into the Directive 2005/78/EC

Engine type	Test cycle	CO	HC	NMHC	CH_4	NOx	PM
Diesel	ESC	1.1	1.05	-	-	1.05	1.1
	ETC	1.1	1.05	-	-	1.05	1.1
Gas	ETC	1.1	1.05	1.05	1.2	1.05	-

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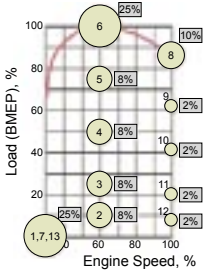
Test cycle EURO I and II / ECE R-49 or 13 Mode Cycle

It is a steady-state diesel engine test cycle used for TA emission testing of HD highway engines up to Euro II standards. Effective October 2000, the R49 cycle was replaced by the ESC cycle.

This cycle is operated through a sequence of 13 speed and load conditions. The final result is a weighted average of the 13 modes.



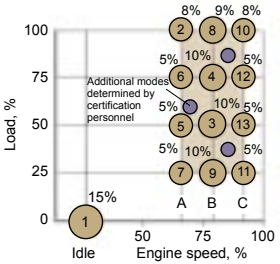
Mode #	Speed	Load, %	Weighting Factors
1	Idle	-	0.25/3
2	Max Torque Speed	10	0.08
3		25	0.08
4		50	0.08
5		75	0.08
6		100	0.25
7	Idle	-	0.25/3
8	Rated Power Speed	100	0.10
9		75	0.02
10		50	0.02
11		25	0.02
12		10	0.02
13	Idle	-	0.25/3

EUROPEAN UNION

Test cycles Euro III and later:
defined by Dir 88/77/EC as amended by Dir 2001/27/EC
Three cycles are accepted:

1) ESC cycle (European Steady-State Cycle)

The test cycle consists of a number of speed and power modes which cover the typical operating range of diesel engines.
It is so determined by 13 steady and 3 random modes.
Emission values are obtained with the weighted mean of emissions on each of the 13 modes.
The three random points are random-tested in a control area.
In this random-test, only NOx emissions are measured. They must not exceed the interpolated value of the 4 nearest modes plus 10%.
This NOx control check ensures the effectiveness of the emission control of the engine within the typical engine operation range.



Mode	Engine Speed	% Load	Weight factor, %	Duration
1	Low idle	0	15	4 minutes
2	A	100	8	2 minutes
3	B	50	10	2 minutes
4	B	75	10	2 minutes
5	A	50	5	2 minutes
6	A	75	5	2 minutes
7	A	25	5	2 minutes
8	B	100	9	2 minutes
9	B	25	10	2 minutes
10	C	100	8	2 minutes
11	C	25	5	2 minutes
12	C	75	5	2 minutes
13	C	50	5	2 minutes

Speed A = n_{lo} + 25% (n_{hi}-n_{lo})
Speed B = n_{lo} + 50% (n_{hi}-n_{lo})
Speed C = n_{lo} + 75% (n_{hi}-n_{lo})

n_{hi} = 70% of the declared maximum net power
n_{lo} = 50% of the declared maximum net power

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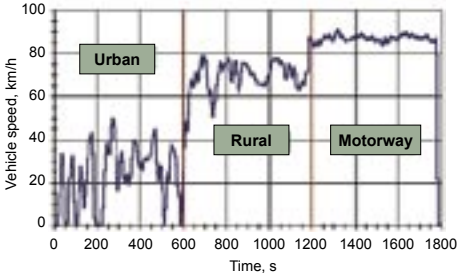
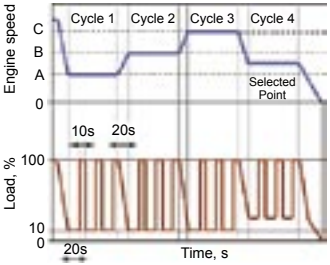
2) ETC Cycle (European Transient Cycle)

This cycle consists of a second-by-second sequence of transient modes.
It is based on road-type-specific driving patterns of HD engines installed in trucks and buses.
It is divided in three parts: 1/3 urban roads, 1/3 rural roads, 1/3 motorways.



3) ELR Test (European Load Response)

Only diesel smoke is measured. ELR cycle is defined by fixed speed sampling and a random sampling.
The random sampling is represented by a random speed and by a random initial load.
Smoke measurements during the sampling must not exceed 20% of the highest value of close speeds or more than 5% of limit value. The biggest one is selected.



US FEDERAL

Californian and US EPA HD standards become close to convergence from 2004

Vehicle classification

The limits apply for heavy-duty vehicles with a GVW ≥ 8.500 lbs (3.856 t)
Engines are classified by end use GVWR:
LHDDE: 8.500 – 19.500 lbs (California begins at 14.000 lbs)
MHDDE: 19.500 – 33.000 lbs
HHDDE: > 33.000 lbs

Testing

Emission testing is generally engine dynamometer based.
Chassis certification is available in place of HD FTP Transient Cycle.
Three sets of tests are required: Transient FTP Test and from MY 2007 (1998 for Consent Decree Manufacturers)
Supplemental Emission Tests. Not To Exceed standards

Diesel Engine – Emission Standards

Previous Emissions Limits (g/bhp.h) - EPA

	Year	HC	CO	NOx	PM
Diesel Heavy Duty Truck	1991-1993	1.3	15.5	5.0	0.25
	1994-1997	1.3	15.5	5.0	0.10
	1998-2003	1.3	15.5	4.0	0.10
Urban Bus	1991-1992	1.3	15.5	5.0	0.25
	1993	1.3	15.5	5.0	0.10
	1994-1995	1.3	15.5	5.0	0.07
	1996-1997	1.3	15.5	5.0	0.05 [1)]
	1998-2003	1.3	15.5	4.0	0.05 [1)]

MY 2004 and later (g/bhp.h)

Applicable for both Heavy Duty Truck engines and Urban buses

	NMHC	NOx+NMHC	CO	PM
Option 1	N/A	2.4	15.5	0.10
Option 2	0.5	2.5	15.5	0.10

[1)] Urban buses: 0.05g/bhp.h (certification) and 0.07g/bhp.h (in use) for 1996 ->

US FEDERAL

Smoke Test Limits

Mode	Accceleration (A)	Lugging (B)	Peak (C)
Opacity %	20	15	50

Family Emissions Limits (g/bhp.h) GVW ≥ 8.500 lbs

NOx + NMHC	PM
4.5 or 4.5 w/ a limit of 0.5 on NMHC (ABT)	0.25

Crankcase emissions added to tailpipe level prior to comparison to standard.
Under Tier 2, PC, LDV and MDV up to 10,000 lbs used for personal transportation have to be type approved following LDV legislation.

MY 2007 and later (g/bhp.h)

	Standard	Phase-In MY			
		2007	2008	2009	2010
NOx	0.20	50%	50%	50%	100%
NMHC (E)	0.14	50%	50%	50%	100%
CO	15.5	100%			
PM	0.01	100%			
Formaldehyde	0.01 [1)]	100%			

Phase-In options:

For MY 2007-2009 combined NOx+NMHC is possible, as defined in EPA, MY 2004. All other requirements to comply w/ MY 2007 standards.
Max authorised 2006 NOx+NMHC TA: 50% of direct production.

ABT and FEL

Model Year	Family Emissions Limits (g/bhp.h)	
	NOx	PM
Bef 2010	2.00	0.02
2010 and later	0.50	0.02

Supplemental Test (see page 27)

- Weighted average exhaust emissions: max 1.0 times applicable emission standards or FEL.
- If NOx FEL < 1,5 g/bhp.h, gaseous exhaust emissions ≤ steady-state interpolated values (Maximum Allowable Emission Limits MAEL).

[1)] CARB 1996 -> 0.05

US FEDERAL

NTE Limits

- Max NMHC or NOx ≤ 1,5 times applicable NMHC or NOx standards or FELs
- If NOx FEL < 1,5 g/bhp.h, NMHC or NOx ≤ 1,25 times applicable NMHC or NOx standards or FELs
- Max PM ≤ 1,5 times applicable PM emission standards or FELs
- Max CO ≤ 1,25 times applicable CO emission standards or FELs

NTE limits apply for altitude ≤ 5,500 feet, ambient conditions of:
0 F -> 100 F at sea level; 0 F -> 86 F at 5500 ft

Crankcase emissions

No crankcase emissions discharged directly into the ambient atmosphere from 2007 MY, except for HD w/ turbochargers: emissions are added to exhaust emission

Portable Emission Measurement Systems (PEMS)

Nov. 2009 In use PEMS enforceable

Otto-Cycle HD

Previous Emissions Limits (g/bhp.h)

From 1991-1997	HC [1]	CO	NOx	CO at Idle [2]
≤ 14.000 lbs GVWR	1.1	14.4	5.0	0,5%
> 14.000 lbs GVWR	1.9	37.1	5.0	0,5%
MY 1998 and later				
≤ 14.000 lbs GVWR	1.1	14.4	4.0	0,5%
> 14.000 lbs GVWR	1.9	37.1	4.0	0,5%

[1] Organic Material Hydrocarbon equivalent (OMHCE) for methanol engines
[2] All gasoline engine w/ catalyst and methanol engines
No crankcase emissions allowed

MY 2005 and later (g/bhp.h)

Emissions	Standards	Option 1		Option 2	
Model Year	2005	2003-2007	2008	2004-2007	2008
NMHC (E) + NOx	1.0	1.5	1.0	1.5	1.0
CO GVWR ≤ 14.000 lbs	14.4				
GVWR > 14.000 lbs	37.1				

US FEDERAL

Standard: 100% compliance in MY 2005
OBD: phase-in 2005-2007 (8.500-14.000 lbs GVWR)
ORVR: phase-in 2005-2006 (8.500-10.000 lbs GVWR)
Option 1: OBD: phase-in 2004-2007 (8.500-14.000 lbs GVWR)
ORVR: phase-in 2004-2006 (8.500-10.000 lbs GVWR)
Option 2: OBD: phase-in 2004-2007 (8.500-14.000 lbs GVWR)
ORVR: phase-in 2004-2006 (8.500-10.000 lbs GVWR)

No crankcase emissions permitted

Idle CO

If no OBD certification: 0,50% of exhaust gas flow at idle

Full life Emissions Standards (at 120,000 miles)

GVW (lbs)	Emissions Limits (g/mile)			
	NOx+NMHC	NMOG	NOx	CO
8.500-10.000	-	0.28	0.9	7.3
10.000-14.000	-	0.33	1.0	8.1

MY 2008 and later

Emission standards

Standards (g/bhp.h)		Phase-in by MY	
		2008	2009
CO	14.4	100%	
NOx	0.20	50%	100%
NMHC (E)	0.14		
PM	0.01		

ABT and FEL (g/bhp.h)

MY	NOx	NMHC
< 2011	0.8	0.4
≥ 2011	0.50	0.3

No crankcase emissions permitted

CALIFORNIA

CARB Standards for 1985-2003 (g/bhp.h)

Year	Total HC or OMHCE [1]	Optional NMHC [1]	CO	NOx		PM	
				Truck	Bus	Truck	Bus
1985	1.3	-	15.5	5.1	5.1	0.60	0.60
1987	1.3	-	15.5	6.0	6.0	0.60	0.60
1991	1.3	1.2	15.5	5.0	5.0	0.25	0.10
1994	1.3	1.2	15.5	5.0	5.0	0.10	0.07
1996	1.3	1.2	15.5	5.0	4.0	0.10	0.05
1996	1.3	1.2	15.5	5.0	0.5-2.5 [2]	0.10	0.05

[1] NMHC gasoline NG and LPG engines OMHCE: methanol engines

[2] Optional NOx standard between 0.5 and 2.5 by 0.5 g/bhp.h increments

CARB Emissions Standards for engines used in Oct. 02 and subsequent (g/bhp.h)

	NOx+NMHC	Optional NOx+NMHC	CO	PM
Option 1	2.4	2.5 (NMHC ≤ 0.5 g/bhp.h)	15.5	0.10
Option 2	N/A	0.3 to 1.8 in 0.3	15.5	0.03 to 0.01

Smoke: Similar to US-EPA smoke test
Acceleration (A): 20%; Lagging (B): 15%; Peak (C): 50% Opacity

Formaldehyde exhaust emissions (NTE)
MY 1993-95: 0.10 g/bhp.h
MY 1996 and subsequent: 0.05 gbhp.h

Standards from 2004

Similar to EPA standards (see page 18)

Standards from 2007

Similar to EPA standards (see page 19)

Clean Fuel Buses Fleet operators have to choose between operating:
- a diesel bus fleet _ Diesel path
- an alternative-fuel bus fleet _ Alternative Fuel Path
- Fleets in South Coast Air Quality Management District must follow altern. path

2007-2009: fleets > 30 must:

a) buy new buses that are 0.2 g/bhph NOx -OR-

b) on 1 to 1 basis, retrofit old buses w/ level 3 PM DECS w/eff. >40% if avail or w/ eff. >25% -OR-

c) obtain E.O. approval for non-conforming bus purchase

CALIFORNIA

Clean Fuel Buses

MY	Diesel Path		Alternative Fuel Path	
	NOx+NMHC	PM	NOx+NMHC	PM
2007	0.2	0.01	0.2	0.01
2008	15% of new purchase ZEB's for large fleet (> 200)			
2010			15% of new purchase ZEB's for large fleet (> 200)	

Additional In-Use Engine Retrofit Requirements:
- Installation of certified (approved) NOx/PM reduction equipment
- Places NO_2 requirement places constraints on devices in 2007
  Max NO_2 increase: 2007-2008: 30%; 2009+: 20%
- Manufacturers may install uncertified equipment as certific. process progresses
- Requires warranty coverage and in-use compliance testing

Emission standards for Diesel or dual-fuel urban bus engine (g/bhp.h)

MY	NOx	PM	NMHC	Formaldehyde	CO
2004-2006	0.5	0.01	0.05	0.01	5.0
2007+	0.2	0.01	0.05	0.01	5.0

CALIFORNIA

HD Idling Emissions Reduction Program

- 2008+ GVWR > 14 k lbs must have automatic engine shutoff if
  a) after 5 min if park. brake on; 15 min if park. brake off
  b) cert. to 30 g/hr NOx over SET/FTR
- Sleeper equipped trucks no longer exempted from idling reduction requirement
- Delay of shutoff for < 30 min allowed for emission dev. performance (dash light requir.)
- Override allowed by PTO operation
  As portion of idling reduction program, auxiliary power supplies are regulated
- Primary engine certified 2007+:
  APU to be certified off-road (w/ Level 3 DPF) or routed ahead of primary engine DPF
- Primary engine 2006 or earlier: APU engine needs to be off-road certified (no DPF required)
  5 min still applies w/in 100 ft of restricted areas.
- Scan tool allowed to extend idling to 60 min for service
- Fuel fired heaters: must comply w/ LEV requirements for fuel fired heaters
  LEV requirement for shutoff above 40F does NOT apply

Foreign Trucks required to meet emission limits when entering the State from outside the US

Proposed Modification to Urban Bus Engines and Vehicles Rules

NOx standard for Diesel Hybrid-Electric Buses: 1.8 g/bhp.h MY 2004-2005

PM standard 0.01 g/bhp.h

Test Procedure: SAE J2711

ZEB regulation: Modified Now 2007.

- Requires operators of fleets ≥ 200 buses on the diesel path to begin Advanced Demonstration Project with required ZEBs to be placed in revenue service by Jan. 1, 2009
- Delays purchase requirements to 2011 for operators on the diesel path and 2012 for operators on the alternative fuelled bus path
- Extends the date to fulfill the full purchase requirements to 2026 for all fleets
- Requires technical review in 2009 by Board
- Credits available to fleet operators for early deployment of ZEBs

Portable Emission Measurement Systems (PEMS)

PEMS enforceable Nov, 2009

CALIFORNIA

Otto-Cycle Medium and Heavy-Duty vehicles (g/bhp.h)

MY	Emission Cat	NMHC+NOx	NMHC	NOx	CO	HCHO	PM
Medium Duty 8.501 – 14.000 lbs GVW							
2004	ULEV	2.4 or 2.5 w/ 0.5 NMHC	-	-	14.4	0.05	-
	SULEV	2.0	-	-	7.2	0.025	-
2005-2007	ULEV	1.0	-	-	14.4	0.05	-
	SULEV	0.5	-	-	7.2	0.025	-
2008, +	ULEV	-	0.14	0.20	14.4	0.01	0.01
	SULEV	-	0.07	0.10	7.2	0.005	0.005
HD > 14.000 lbs GVW							
2004	-	2.4 or 2.5 w/ 0.5 NMHC	-	-	37.1	0.05	-
2005-2007	-	1.0	-	-	37.1	0.05	-
2008, +	-	-	0.14	0.20	14.4	0.01	0.01

Idle CO: if aftertreatment technology is used and not certified OBD max CO: 0,50%

Compression Ignition Medium Duty optional standards (8,601-14,000 lbs GVW) (g/bhp.h)

MY	Em. Cat	CO	NMHC+NOx	NMHC	NOx	HCHO	PM
2004 - 2006	ULEV Opt A	14.4	2.5 NMHC ≤ 0.5	-	-	0.050	0.10
	ULEV Opt B	14.4	2.4	-	-	0.050	0.10
2007, +	ULEV	15.5	-	0.14	0.2	0.050	0.01
	SULEV	7.7	-	0.07	0.1	0.025	0.005

In-use compliance: 90 000 miles

Phase-in: (see page 19)

ESC and NTE test: from MY 2005

Identical to ESC and NTE HD diesel

NTE: max 1,25 times FTP emission standards

Operation within the NTE control zone

ESC: Emissions equivalent to FTP emissions standards

Emission Useful Life Standards and Emissions Warranty

	CARB	EPA
USEFUL Life (Yr/mi/hours)		
LHDDE	10/110k	8/110k[2)]
MHDDE	10/185k	10/185k
HHDDE	10/435k/22k	10/435k/22k
Emissions Warranty [1)]		
All Class	5/100k/3k	5/100k

[1)] Longer of listed and mechanical warranty length

[2)] 10 yrs for PM and NOx

US REGULATION

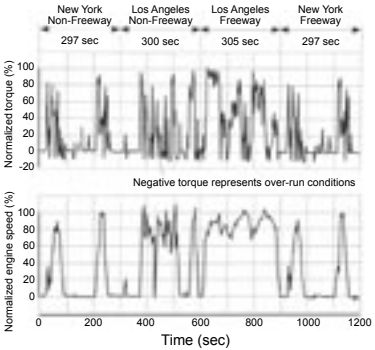
A. FTP Test Cycles

1. Heavy Duty Diesel Transient Cycle (HDDTC)

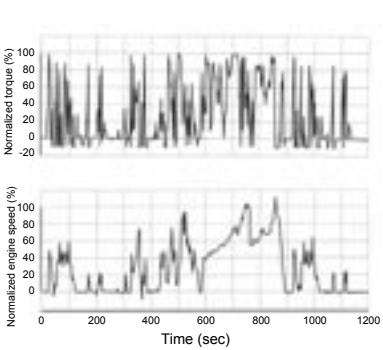
Test cycle comprised of four phases representing different driving conditions.

Phases one and four are the same.

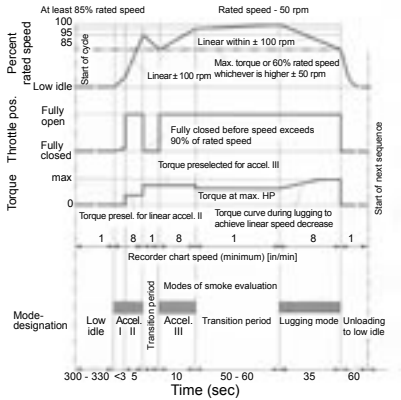
Test is a cold start followed by a 20 min soak and then a repeat of the test cycle.



2. Heavy Duty Gasoline Transient Cycle (HDGTC)



3. Diesel Smoke



B. Supplemental 2004 and 2007 test cycles

1. Steady State Test discrete – Mode Cycle up to MY 2009

As a result of the Consent Decree of 1998, most engine manufacturers are required to meet the applicable FTP transient emission standard during the SET schedule (among other requirements).

Supplement Steady State test (SSS) is based on the EU ESC cycle (see page 18)

It contains 13 fixed modes and 3 by random selected modes.

The alternate procedure for steady state test may be used through MY 2009.

The ramped-modal test is mandatory in MY 2010.

2. Ramped Modal Cycle Steady-State SET, MY 2007 (Warmed-up engine test)

As an alternative the steady state cycle can be made with a discrete mode cycle through MY 2009.

Optional through MY 2009, mandatory from MY 2010.

US REGULATION

Ramped Modal test involves a single and continuous emission measurement as the engine operates over the test modes in a defined sequence.
It also includes short transition segments between modes.

RMC Mode	Time in Mode (s)	Engine Speed	Torque (%)
1a Steady-state	170	Warm Idle	0
1b Transition	20	Linear Transition	Linear Transition
2a Steady-state	170	A	100
2b Transition	20	A	Linear Transition
3a Steady-state	102	A	25
3b Transition	20	A	Linear Transition
4a Steady-state	100	A	75
4b Transition	20	A	Linear Transition
5a Steady-state	103	A	50
5b Transition	20	Linear Transition	Linear Transition
6a Steady-state	194	B	100
6b Transition	20	B	Linear Transition
7a Steady-state	219	B	25
7b Transition	20	B	Linear Transition
8a Steady-state	220	B	75
8b Transition	20	B	Linear Transition
9a Steady-state	219	B	50
9b Transition	20	Linear Transition	Linear Transition
10a Steady-state	171	C	100
10b Transition	20	C	Linear Transition
11a Steady-state	102	C	25
11b Transition	20	C	Linear Transition
12a Steady-state	100	C	75
12b Transition	20	C	Linear Transition
13a Steady-state	102	C	50
13b Transition	20	Linear Transition	Linear Transition
14a Steady-state	168	Warm Idle	0

3. Load Response Test Applicable to HD diesel, MY 2004-2007.
This test is conducted on a dynamometer. The purpose is to measure the brake specific gaseous and particulate emissions from a HD diesel engine as it is suddenly loaded, with its fuelling lever, at a given engine operating speed. Results of this test are not compared to emission standards.

US REGULATION

4. Not To Exceed (NTE) test

As a result of the Consent Decree of 1998, most engine manufacturers are required to maintain engine emissions below a limit of 1,25x applicable FTP standards during engine operation in a speed-load zone below the engine's torque curve.

Limit increases to 1,5 X FTP standard in MY 2007.

No specific drive cycle.

Applicable to steady state AND transient maneuvers at varying ambient temperatures and up to 5500 ft elevation.

Emissions measured over intervals a minimum of 30 sec in length.

EVAPORATIVE EMISSION LIMITS

EPA

MY	GVWR (Lbs)	3 Diurnal + Hot soak [1]	2 Diurnal + Hot soak	Running Loss	Refuelling spitback [2]
1998	≤ 14,000	3.0 g/test	3.5 g/test	0.05 g/test	1.0 g/test
MY, +	> 14,000	4.0 g/test	4.5 g/test	0.05 g/test	-
2008	≤ 14,000	1.4 g/test	1.75 g/test	0.05 g/test	1.0 g/test
MY, +	> 14,000	1.9 g/test	2.3 g/test	0.05 g/test	-

[1] Evaporative emissions limits for NG and LPG fuelled HDDC engines

[2] Methanol – Gas fuelled engines only

CARB

From 2004 MY, > 8,500 lbs

3 Diurnal + Hot soak	Running Loss	2 Diurnal + Hot soak
1.00 g/test	0.05 g/test	1.25 g/test

Phase-in schedule:

MY 2004: 40% MY 2005: 80% MY 2006, Y: 100%

JAPAN

Vehicle categories

Original weight category: vehicles (trucks, buses) > 2,5t GVW

From 2001 standards: gasoline vehicles > 3,5t GVW. From 2005 long term standards: diesel vehicles > 3,5t GVW

Initial Standards

Diesel engines		**CO**		**HC**		**NOx**		**PM**		**Smoke [3]**
		Max [1]	**Mean [2]**	**Max [1]**	**Mean [2]**	**Max [1]**	**Mean [2]**	**Max [1]**	**Mean [2]**	
Japan 88/89 (ppm) 6-Mode test	GVW > 2,5t	980	790	670	510	520 (DI) 350 (IDI)	400 (DI) 260 (IDI)	-	-	-
Japan 94 (g/kWh) 13 Mode test	2,5t < GVW ≤ 12t	9,2	-	3,8	-	5,8	-	0,49	-	40%
	GVW > 2,5t	9,2	7,4	3,8	2,9	6,8 (IDI) 7,8 (DI)	5.0 (IDI) 6.0 (DI)	0,96	0,70	40%
Japan 97 [4] (g/kWh)	> 2,5t	9,2	7,4	3,8	2,9	5,8	4,5	0,49	0,25	40%
Gasoline engines (13 Mode test)										
Japan 98 (g/kWh)	> 2,5t	68	51	2,29	1,80	5,9	4,5	-	-	-

[1] To be met as type approval limit if sales are less than 2000 per vehicle model per year and generally as an individual limit in series production

[2] To be met as a type approval limit and as a production average

[3] Smoke measured under 3 full load conditions (at 40, 60 or 100% of rated speed) and under free load acceleration

[4] 2,5T – 3,5T: introduction in 1997; 3,5T – 12T in 1998; > 12T in 1999

JAPAN

New Short Term Standards (13-Mode)

Diesel engines

Implementation dates:	2,5t < GVW ≤ 12t	GVW > 12t
New vehicles	From Oct. 03 to Oct. 05	From Oct. 04 to Oct. 05
Existing and Imported vehicles	From Sept. 04 to Sept. 07	From Sept. 05 to Sept. 07

CO (g/kWh)		HC (g/kWh)		NOx (g/kWh)		PM (g/kWh)		Smoke
Max	Mean	Max	Mean	Max	Mean	Max	Mean	-
3.46	2.22	1.47	0.87	4.22	3.38	0.35	0.18 [1)]	25%

[1)] JAMA voluntary adopted a level of 0.05 g/kWh

Gasoline engines (GVW > 3,5T)

Implementation dates: new vehicles: from Oct. 01
Existing and imported vehicles: from Sept. 03

Exhaust emissions:

CO (g/kWh)		HC (g/kWh)		NOx (g/kWh)	
Max	Mean	Max	Mean	Max	Mean
26.0	16.0	0.99	0.58	2.03	1.40

Evaporative emissions:

Running	25 sec idle 4x 11-Mode + 3x (24 sec idle + 10-15 Mode)
Hot Soak Loss (HSL)	1 Hr SHED at 27 ± 4°C
Diurnal Breathing Loss (DBL)	1 heat build in 24 hours Cycle from 20°C - 35°C
Emission standard: HSL + DBL: 2 grams/test	

Japan 05 Standards

Diesel vehicles > 3,5T GVW
HC will be measured as NMHC
Test cycle: New JE05 transient cycle (See page 33)

	CO (g/kWh)		NMHC (g/kWh)		NOx (g/kWh)		PM (g/kWh)		Smoke
	Max	Mean	Max	Mean	Max	Mean	Max	Mean	-
Diesel	2.95	2.22	0.23	0.17	2.7	2.0	0.036	0.027	25%
Gasoline	21.3	16.0	0.31	0.23	0.9	0.7	-	-	-

Application: from Oct. 05 for domestic new vehicles
from Sept. 07 for existing and imported vehicles

JAPAN

Regional Diesel PM Emissions standards

GVW > 2.5T	Prefecture			
	Tokyo	Saitama	Kanagawa	Chiba
From 2003	0.25 g/kWh			
From 2006	0.180 g/kWh		No plan	

Vehicles not conforming to the required PM standards will not be operated within the specified region.

Two exceptions: - vehicle less than 7 years old
- vehicle fitted with a PM trap

Durability:

Diesel: 3.5 < GVW ≤ 8t: 250,000 km
8 < GVW ≤ 12t: 450,000 km
GVW > 12t: 650,000 km

Gasoline: 180,000 km

OBD: mandatory

Diesel engine smoke: test procedure Japan 4-Mode Opacity limit: 25%

Post New Long Term Emission Standards

Trucks and Buses GVW > 3.5t (Mean/Max)

g/KWh	PM	NOx	NMHC	CO
Diesel	0,010/0,013	0,7/0,9	0,17/0,23	2,22/2,95
Gasoline/LPG	0,010/0,013	0,7/0,9	0,23/0,31	16,0/21,3

PM for gasoline veh apply only to DI veh equipped w/ NOx absorber cat

Application date: Domestic vehicles
Diesel: Heavy Duty > 3,500 kg and ≤ 12,000 kg: 01 October 2010
Gasoline: 01 October 2009
Imported vehicles: 11 months later

Test cycle: JE05

Diesel Sulfur content: 10ppm

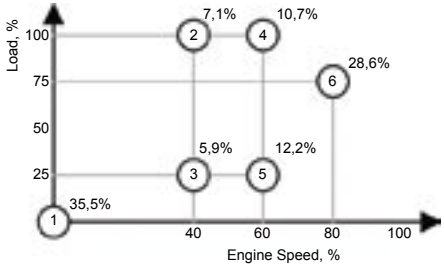
2015 Fuel Efficiency Standards for Diesel truck and bus

GVW(t)	3,5-7,5				7,5-8	8-10	10-12	12-14	14-16	16-20	>20
Max load cap (t)	<1,5	1,5-2	2-3	>3	-						
2015 FE	10,83	10,35	9,51	8,12	7,24	6,52	6,00	5,69	4,97	4,15	4,04

JAPAN DRIVING CYCLES

6-Mode cycle

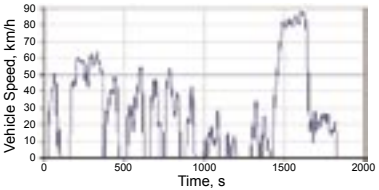
The engine was tested over 6 different speed and load conditions.
The modes were ran in sequence and the duration of each mode was 3 min.
Measurements were expressed in ppm (volumetric concentration)



New driving cycle JE05 (also known as ED12)

The JE05 cycle becomes effective from 2005 for both diesel and gasoline applications. It is based on Tokyo driving conditions. The test cycle is defined through vehicle speed Vs. time points, that's requiring conversion to engine conditions.

Duration: 1829 s Average speed: 26,94 km/h
Max speed: ≈ 88 km/h



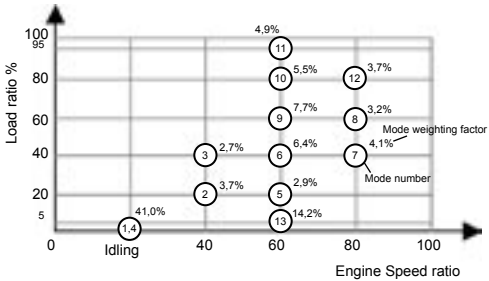
JAPAN DRIVING CYCLES

13-Mode cycle

The 13-Mode cycle replaced the 6-Mode cycle. It includes a sequence of 13 steady-state modes. Measurements are expressed in g/kWh.
The test represents low-speed driving conditions, specified by low average engine loads and low exhaust temperatures.

Diesel 13-Mode cycle

Mode	Speed	Load	Weighting factor
	% of nominal	%	
1	Idle	-	0,410/2
2	40	20	0,037
3	40	40	0,027
4	Idle	-	0,410/2
5	60	20	0,029
6	60	40	0,064
7	80	40	0,041
8	80	60	0,032
9	60	60	0,077
10	60	80	0,055
11	60	95	0,049
12	80	80	0,037
13	60	5	0,142

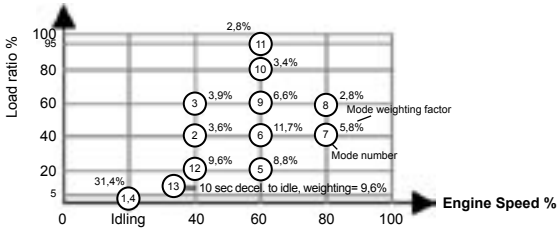


JAPAN DRIVING CYCLES

Gasoline 13-Mode cycle

Mode	Speed	Load	Weighting factor
	% of nominal	%	
1	Idle	-	0,314/2
2	40	40	0,036
3	40	60	0,039
4	Idle	-	0,314/2
5	60	20	0,088
6	60	40	0,117
7	80	40	0,058
8	80	60	0,028
9	60	60	0,066
10	60	80	0,034
11	60	95	0,028
12	40	20	0,096
13	40 [1)]	20 [1)]	0,096

[1)] Deceleration to idle



REQUIREMENTS IN OTHER AREAS OF THE WORLD

Country	Requirement
Argentina	Vehicles with max mass > 3,856kg – ECE 49 Euro III: TA: 01 Jan 06 – Manufacture and import: 01 Jan 07 Euro IV: TA: 01 Jan 09 – Manufacture and import: 01 Jan 11
Australia	ADR 80/02:Euro IV: From 01 Jan 07 for new model vehicles From 01 Jan 08 for all produced vehicles US04 or Japanese 05 considered as alternative ADR 80/03: Euro V: From 01 Jan 10 for new model vehicles 01 Jan 11 for all produced vehicles US 07 or Japanese 05 considered as alternative 10ppm Sulfur diesel: from 01 Jan 09
Brazil	Proconve P-5, equiv. Euro III: from 01 Jan 06 Proconve P-6, equiv Euro IV: from 01 Jan 09 - postponed New proposed introduction date: Jan 2013 Durability: 160,000 km or 5 years Smoke: From Jan 2000: ECE R24.03
Canada	Canada Tier 2 requirements, similar to US Tier 2 No emission averaging, banking and trading option
Canada (2)	Average NOx standards: 07 MY: 0,20 gpm; 08MY: 0,14 gpm; 09MY: 0,07 gpm
Chile	Diesel HD: from 01 Oct 2006, Euro III or US98 HD Diesel Gasoline HD:from 01 Sep 98, CO:37.1; HC:1.9; NOx:5.0g/bhp*h Santiago: EU III/US98 w/ DPF and OBD: new bus: 2009; new truck: 2010 EU IV/US07 w/ DPF and OBD: new bus, new truck: 2012
Colombia	From 97: US 13 procedure CO: 25.0; HC+NOx: 10.0g/hph Buses: EU II Diesel smoke: from 01, free acceleration opacity test limits: 40%
Costa Rica	US HDTTC (US 91) or ECE 49 (Euro I) ECE 24.03 (smoke)
Croatia	ECE 49.02 + ECE 24.03
Ecuador	US94 or EU II
Hong-Kong	From 01 Oct 07: Euro IV or US HDV 2005 or Japan HDV 2005 E-OBD (EC 2005/55) or OBD US of J-OBD Proposal: EU V from 2011
Iceland	Euro standards adopted

Delphi Probe Air Meters

Delphi Probe Air Meters feature a patented "dimple" flow management design for outstanding performance. And, heated sensing elements offer proven durability with more than 100 million in the field over the past 10 years.

Delphi Smart Remote Actuator

Offers durability, adaptability and flexible mounting options.

Integrated electronics provide improved EGR flow control with enhanced accuracy resolution.

For variable geometry applications, it also manages turbo control.

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REQUIREMENTS IN OTHER AREAS OF THE WORLD

India	Test cycle: ECE 49 - Mode 13 EU II: 04/2005: nation wide EU III: 04/2005: Delhi + selected cities; 04/2010: nation wide EU IV: 04/2010: Delhi + selected cities; 2014: nation wide Inter-states buses and trucks in use: Delhi: 01 Apr 07: min EU I; 01 Apr 11: min EU II Other cities: 01 Apr 08: Euro I National Capital Region: proposal of restriction of vehicle: vehicle > 10 yrs forbidden; EU III mandatory for all goods vehicles
Indonesia	Diesel M2, M3, N2, N3: ECE 49.02 Stage 2 New type motor vehicles: 01 Jan 05 Motor vehicles in current production: 01 Jan 07
Israel	European standards applicable: EU V (01 Oct 08); EU VI (31 Dec 12) For vehicle produced in USA: 40CFR Part 86
Malaysia	HD Diesel engines: Euro II
Mexico	Equivalent to US federal regulations (HDDTC) from 1998 From July 2008: US 2004 or Euro IV
Nepal	Since Jan 2000, Euro I

New Zealand	Requir. for veh. presented for inspection in NZ for the first time: - Gasoline: As of 2007 New model: ADR 80/01, US 98 or Japan 00/02 Existing model: ADR 80/01, US 98 or Japan 00/02 - Diesel: As of 2008 New mod: ADR 80/01 and 30/01, EU IV, US04 or Jap 02/04 All mod: ADR 80/01 and 30/01, EU III, US04 or Jap 02/04 EU IV required from Jan 2009 - EU V TA: 01Jan11; FR: 01Jan12
Norway	Euro standards adopted
Peru	Euro III: form 2007
Philippines	From 01 Jan 03: Euro I, ECE 49.02
PR of China	Applicable standards: GB 17691-2005 equivalent to EU standards Beijing: Stage III (EU III - ESC+ELR): Dec 05 Stage IV (EU IV - ESC+ELR+ETC): Jan 08 Stage V (EU V - ESC+ELR+ETC): Jan 2012 Nation wide: Stage III: TA: 01 Jan 08

REQUIREMENTS IN OTHER AREAS OF THE WORLD

<table>
<tr><td>PR of China (2)</td><td>Stage IV: TA: 01 Jan 2013
Durability: Recommended test cycle: Japan 05
Gasoline: 80,000 km or 5 yrs; shortest test mileage: 50,000 km
Diesel: (mileage (km); Util. time (yr); shortest test mileage (km))
<table>
<tr><th>M2</th><th>M3 (GVM ≤ 7,5t)</th><th>M3 (GVM > 7,5t)</th><th>N2</th><th>N3 (GVM ≤ 16t)</th><th>N3 GVM > 16t</th></tr>
<tr><td>80,000</td><td>100,000</td><td>250,000</td><td>100,000</td><td>100,000</td><td>250,000</td></tr>
<tr><td>5</td><td>5</td><td>6</td><td>5</td><td>5</td><td>6</td></tr>
<tr><td>50,000</td><td>60,000</td><td>80,000</td><td>60,000</td><td>60,000</td><td>80,000</td></tr>
</table></td></tr>
<tr><td>Russia</td><td>Ecological Class 2 (ECE 49.02 Stage 2) from 01 Jan 06
Ecological Class 3: (ECE 49.04-A) from 01 Jan 08
Ecological Class 4: (ECE 49.04-B1) from 01 Jan 10
Ecological Class 5: (ECE 49.04-B2 C) from 01 Jan 14</td></tr>
<tr><td>Saudi Arabia</td><td>ECE R49 (Saudi standards 673/1991)</td></tr>
<tr><td>Singapore</td><td>Euro II from 01 Jan 01</td></tr>
<tr><td>South Africa</td><td>ECE 49-02 B (EU II); Alternative: US 98, Japan 98 or ADR 80/00
New TA: Jan 06; all production: Jan 10
Proposed EU III new TA: Jan 2010; all production: Jan 2012</td></tr>
</table>

South Korea	From Jan 03: EU III equiv. Test cycle: Jap Diesel 13-Mode EU V from Jul 09 (TA); Jul 2010 (FR) Durability: 300.000 km or 10 yrs
Switzerland	EU standards adopted
Taiwan	US HDDTC from 01 Jul 93; From 2006: EU IV
Thailand	Diesel HDV Euro III (TIS 2315-2550) From 2012: EU IV (TIS 2315-2551)
Turkey	From 2007: EU IV
Vietnam	ECE 49-02 / Euro II (TCVN 6565-1999) Proposal: Euro III in 2008 Euro IV in 2010 Euro V: declared application time in 2010

ON BOARD DIAGNOSTICS

OBD permits rapid detection of failure of emission critical components and systems on vehicles.

European EOBD from Euro IV

OBD tests are made over the ESC test cycle where the length of each mode is reduced to 60 seconds.

Condition for malfunction Emissions increase above total threshold	NOx (g/kWh)	PM (g/kWh)
Row A (2005) EURO IV	7.0	0.1
Row B (2008) EURO V	7.0	0.1
Row C (EEV)	7.0	0.1

OBD stage I (EURO IV): Diesel engines only

TA: from 01 Oct. 2005 FR: from 01 Oct. 2006

Monitoring area

- Reduction in the efficiency of the catalyst
- Complete removal of a catalyst
- Reduction in the efficiency of the DeNOx System
- Reduction in the efficiency of the diesel particulate system
- Reduction in the efficiency of the combined DeNOx–particulate filter system

As an alternative, OBD systems may monitor for major failure of:

- Catalyst (separated unit or part of a DeNOx system or of a diesel particulate filter)
- DeNOx system
- Particulate filter
- Combined DeNOx – particulate filter system

OBD stage II (EURO V): applicable for diesel and gas engines

TA: from 01 Oct. 2008

FR: from 01 Oct. 2009

Monitoring area: Stage I monitoring area, except monitor for MFF only not enough + Interface between the engine electronic control unit (EECU) and any other powertrain or vehicle electrical or electronic system for electrical disconnection.

Additional requirements for both stage I and stage II

- Monitoring of the fuel-injection system electronic, fuel quantity and timing actuator for circuit continuity and total functional failure.
- Any other emis. rel. component (air flow, EGR, etc) if a malfunction causes increase above threshold.
- Check of circuit continuity of any other emis. rel. component connected to computer, unless monitored otherwise
- In case of after treatment system using a consumable reagent, monitoring of lack of any required reagent

General Requirements:

- Standardisation of emission related fault codes, data transfer, diagnostic tools and connector according to ISO standards
- Repair information to be provided, excluding information covered by intellectual rights or that constitutes specific know-how of manufacturers/suppliers

ON BOARD DIAGNOSTICS

Requirements for Correct Operation of NOx Control Measures

Application date: TA from 09 Nov 2006 FR from 01 Oct 2007

1) In case of engine systems requiring a reagent, NH_3 emissions over the applicable emissions test cycle, do not exceed 25 ppm (mean value).

2) Engine NOx control
- Incorrect operation of the NOx control monitored => MIL
- NOx level > 1,5 g/kWh above the applicable NOx limit (See p. 10) => MIL
- NOx level exceed OBD (7,0 g/kWh) => torque limiter activation
- Record of the fault for at least 400 days or 9600 hours of engine operation
- Alternative method possible if use of EGR only for NOx emission control

3) Reagent control
- Warning when level of reagent < 10% of the tank or < level corresponding to the driving distance possible w/ the fuel reserve level
- Reagent consumption to be monitored
- Consumption deviated by > 50% => torque limiter activation
- Reagent indicator on dashboard
- Reagent tank empty => torque limiter activation
- Wrong reagent quality/ concentration => torque limiter activation
- Interruption in reagent dosing activity => torque limiter activation

4) Torque limiter value of:
- Max 60% of max torque for N3 > 16 tons, M1, M3/III and M3/B > 7,5 tons
- Max 75% of max torque for N1, N2, N3 ≤ 16 tons, 3.5 < M1 < 7.5 tons M2, M3/I, M3/II, M3/A, M3/B ≤ 7,5 tons

Deactivation of the torque lim. not feasible by switch or maintenance tool

5) Operating conditions of the emission control monitoring system
- ambient temperature: -7°C –> 35°C
- altitude below 1600 m
- engine coolant temperatures > 70°C

6) Emission control monitoring system monitored for
- electrical failures
- removal or deactivation of any sensor
- if failure not remedied within 50 hrs engine operation => torque limiter

EU VI OBD requirements: not known yet at date of printing

ON BOARD DIAGNOSTICS

EPA HD OBD

Identifies deteriorations and malfunctions to exceed the defined threshold values according to HDDTC or HDGTC procedures.
Driver is notified upon detection (MIL).
Standardization of emission related fault codes, data transfer, diagnostic tools and connector according to ISO standards.

Monitoring area

- Catalysts and particulate traps
- Engine misfire
- Oxygen sensors
- Evaporative leak
- Other emission control systems (EGR)
- Other emission related engine components

California OBD II compliance as an option.

EPA OBD phase-in, GVWE > 14,000 lbs

MY	OTTO & Diesel Cycle Phase-In
2010	
2011	
2012	
2013	100% compliance [1)]

[1)] Alternative fuel waivers available

ON BOARD DIAGNOSTICS

CARB OBD requirements MY 2010,+ (HD >14.000 lbs)

Monitoring: NOx conversion efficiency for SCR
NOx absorber and lean NOx catalysts
Functional check of any other SCR system components
PM monitoring systems when PM > Defined threshold values
Fuel system and misfire
DPF too frequent or infrequent regeneration
Comprehensive component monitoring (input/output devices)
Crankcase ventilation system
Engine cooling system
EGR
Boost pressure control system
Variable valve timing and/or control
Exhaust gas sensor
Evaporative system (gasoline only)
Cold start emission reduction strategy (gasoline only)
HC conversion efficiency for oxidation catalysts
NMHC conversion catalysts (all, including ammonia slip catalysts)
Secondary air delivery system

From 2010-2019 MY, exemptions apply for alternate-fuelled vehicles

CARB OBD proposals MY 2013,+ (HD > 14.000 lbs)

Monitoring: In-use Monitoring Frequency
NMHC Catalyst: Proper feedgas to SCR catalyst (NO to NO_2 conversion)
Clean-up catalysts (for use downstream of SCR catalysts)

WWH - OBD: Worldwide Harmonized Heavy Duty OBD

Adopted on November 15, 2006
The GTR is split in two parts:
- generic OBD requirements (out of booklet scope)
- specific OBD emissions related

The OBD systems will have to:
- detect malfunctions
- indicate their occurrence by means of a malfunction indicator (MI)
- identify the area of these malfunctions
- store this information in computer memory
- communicate this information off-board

It applies to HD diesel fuelled C.I. engine systems
OBD test cycle: WHTC (see page 4)

WWH – OBD: Worldwide Harmonized Heavy Duty OBD
Classification of malfunctions

Class A: malfunction when OBD threshold limits (OTL) are assumed to be exceeded

Class B1: malfunction can lead to emissions above the OTLs but for which the exact influence on emission cannot be estimated

Class B2: malfunction that can influence the emissions but not to a level that exceeds the OTLs

Class C: malfunction that can influence the emissions but to a level that would not exceed the regulated emission limits

Monitoring area:
Variable valve timing system
Electric, electronic components monitoring
Engine Cooling system monitoring
Lean NOx trap or NOx adsorber - Selective Catalytic Reduction System
Diesel Oxidation Catalyst - Diesel particulate filter – Exhaust Gas Sensor
Crankcase ventilation system
Fuel System
Air Handling and Turbocharger - Boost pressure control system - EGR
Engine misfire – Idle Speed ControlSystem

Performance Requirements:
If WHTC GTR is used for certification purpose, the world harmonized OBD test cycle applies. Relevant regional OTL's have to be applicable accordingly. Harmonized OBD performance requirements will evolve with the harmonization of the test cycles, the emission limits and the process for calculating the OTL's

WWH-OBD GTR Harmonization Steps

	Step 1	Step 2	Step 3
Test cycles (emissions/OBD)	Non harmonized or harmonized	Harmonized	Harmonized
Emissions Limits	Non harmonized	Non harmonized	Harmonized
OTL's calculation process	Non harmonized	Harmonized	Harmonized
OTL's	Regionally defined	Regionally calculated	Harmonized

PRODUCTION CONFORMITY TESTING

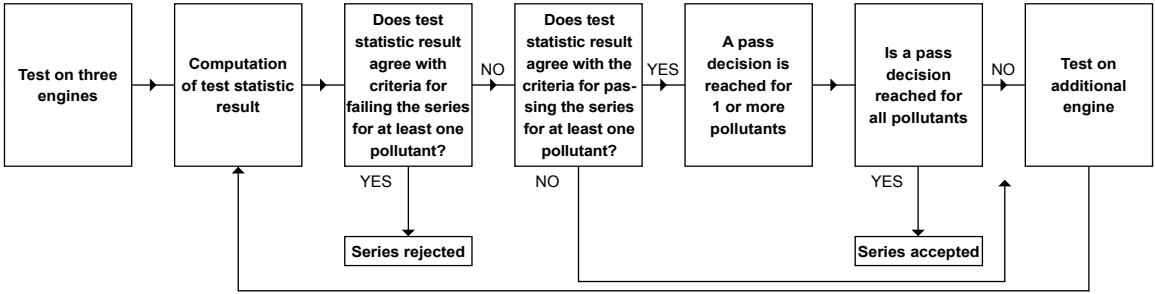
EU Procedure

The tests are carried out on newly manufactured engines.

At the request of manufacturer, tests may be carried out on engines which have been run-in up to a max of 100 hours

Tests to be conducted on ESC / ELR or on ETC as defined for T.A.

Tests may be conducted with commercial fuel. At the manufacturer's request, the reference fuel may be used

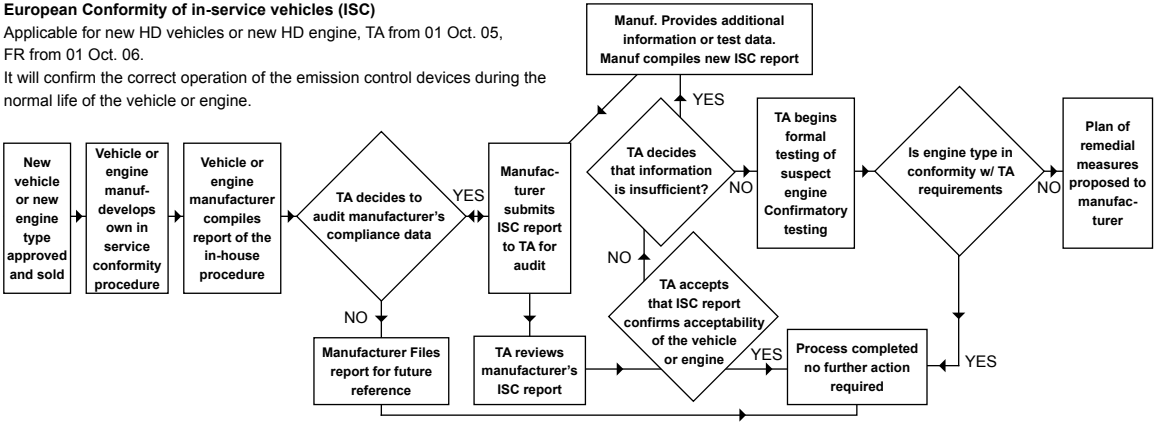


IN SERVICE CONFORMITY TESTING

European Conformity of in-service vehicles (ISC)

Applicable for new HD vehicles or new HD engine, TA from 01 Oct. 05, FR from 01 Oct. 06.

It will confirm the correct operation of the emission control devices during the normal life of the vehicle or engine.



In SERVICE CONFORMITY TESTING

US In use testing

Applicable to HD > 8500 lbs

HC, CO and NOx emission from 2005

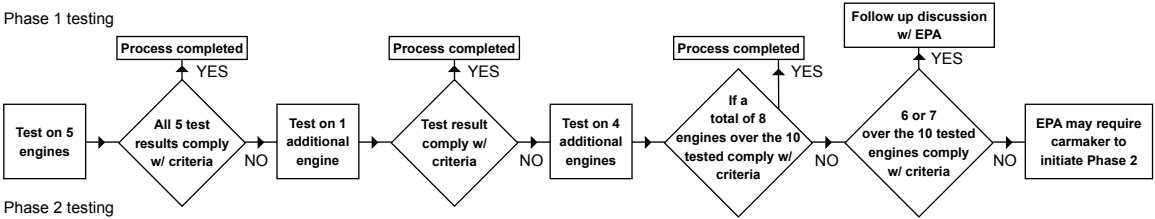
PM emissions from 2006

Based on families selected by EPA: - Up to 25% of engine families/year

- Every 4 years period, max average number of engine families certified over that 4 years period

The average emissions for each pollutant must remain at or below the NTE threshold

Phase 1 testing



Phase 2 testing

For any reason, carmakers can be requested to test 10 additional engines.

EPA may select a certain subset of the engine family, force specific test conditions, define a period when testing and reporting have to be done.

In SERVICE CONFORMITY TESTING

CARB Proposal for in-use conformity

- All HD With GVW > 14.000 lbs (6.350 kg) fuelled by diesel or alternative diesel but not NG
- Compliance with Best Available Control Technology (BACT)

- **Phase 1**: phase-in: 2010-2013
  + NOx emission: max 2007 NOx emission limit
  + all vehicles in the fleet to be equipped with verified diesel emissions control systems for PM

- **Phase 2**: phase-in: 2017-2021
  + Max NOx emission similar to 2010 emissions standards
  + PM: any vehicle equipped with highest level of PM control system

Many thanks to the people around the world who helped to put this book together!

The information contained in this booklet is general in nature. Although Delphi believes the information provided is accurate as of its date of publication, the applicable laws and regulations in this area are complex and subject to change, and Delphi makes no representation or warranty regarding the information and assumes no obligation to update or revise this information. Please consult the full text of all applicable government laws, rules and regulations prior to taking any action in respect of the matters described in this booklet.

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REFERENCE TEST FUELS EUROPE

EU – Diesel reference fuel Dir 98/70/EC as amended by Dir 2002/80/EC*

Parameter	Unit	Limits
Cetane	-	52-54
Density at 15°C	kg/m^3	833-837
Distillation T50	°C	≥ 245
T95	°C	345-350
FBP	°C	≤ 370
Flash point	°C	≥ 55
CFPP	°C	≤ -5
Viscosity at 40°C	mm^2/s	2.5 - 3.5 [1)]
Polycyclic aromatics	% m/m	3.0 - 6.0
Sulfur	ppm	≤ 300 [2)]
Copper Corrosion	-	≤ 1
Conradson C residue (10% DR)	% m/m	≤ 0.2
Ash content	% m/m	≤ 0.01
Water content	% m/m	≤ 0.02
Neutralisation (strong acid) #	mg kOH/g	≤ 0.02
Oxidation stability	mg/ml	≤ 0.025
FAME	max 5% vol	

Ethanol for diesel engines (ISO 4259)

Parameter	Unit	Limits
Alcohol, mass	% mass	≥ 92,4
Other alcohol than ethanol	% mass	≤ 2
Density at 15°C	kg/m^3	795-815
Ash content	% mass	≤ 0,001
Flash point	°C	10
Acidity (as acetic acid)	% mass	≤ 0,0025
Neutralisation # (strong acid)	KOH mg/l	≤ 1
Colour	According to scale	≤ 10
Dry residue at 100°C	mg/km	≤ 15
Water content	% mass	≤ 6.5
Aldehydes (as acetic acid)	% mass	≤ 0,0025
Sulfur	ppm	≤ 10
Esters (as ethylacetate)	% mass	≤ 0.1

[1)] From EURO IV: 2.3 – 3.3 [2)] Mandatory diesel Sulfur level for EURO IV: ≤ 10ppm

NB: Market diesel fuel: from 01 Jan 2009: Sulfur ≤ 10 ppm

* Dir 98/70 amendment adopted by EU Parliament on 17 Dec 08 (to be endorsed by EU Council): Max FAME: 7%; Polycyclic aromatics: Max 8%

- New diesel quality with FAME > 7%, with information on biofuel content allowed
- Countries w/ severe winter conditions: possibility of max distillation T10: 180°C

REFERENCE TEST FUELS EUROPE

Natural Gas (NG)

Reference Fuels	Characteristics	Units	Basis	Limits
G_R	Methane	-	87	84 - 89
	Ethane	-	13	11-15
	Balance [1]	% mole	-	≤ 1
	Sulfur	ppm	-	≤ 10
G_{23}	Methane	-	92,5	91,5 - 93,5
	Balance [2]	% mole	-	≤ 1
	N_2	-	7,5	6,5 - 8,5
	Sulfur	ppm	-	≤ 10
G_{25}	Methane	-	86	84 - 88
	Balance [2]	% mole	-	≤ 1
	N_2	-	14	12 - 16
	Sulfur	ppm	-	≤ 10

[1] Inerts + C_{2+} [2] Inerts (≠ from N_2) + C_2 + C_{2+}

European market fuels are available in two ranges:

The H range, whose extreme reference fuels are G_R and G_{23}

The L range, whose extreme reference fuels are G_{23} and G_{25}

Liquefied Petroleum Gas (LPG)

Parameter	Units	Limits Fuel A	Limits Fuel B
Motor octane #	-	≥ 92,5	≥ 92,5
C_3 – content	% vol	48 - 52	83 - 87
C_4 – content	% vol	48 - 52	13 - 17
$< C_3, < C_4$	% vol	≤ 2	≤ 2
Olefins	% vol	≤ 12	≤ 14
Evaporation residue	ppm	≤ 50	≤ 50
Sulfur [1]	ppm	≤ 50	≤ 50
Hydrogen Sulphide	-	None	None
Copper strip corrosion	Rating	Class 1	Class 1
Water at 0°C	-	Free	Free

[1] From EURO IV, V ≤ 10 ppm

REFERENCE TEST FUELS EUROPE - NRMM

NRMM EU Diesel Reference Fuel (CEC RF-75-T-96)

Parameter	Unit	Stage I/II		Test Method
		Min	Max	
Cetane Number	-	45.0	50.0	EN-ISO 5165
Density at 15°C	kg/m^3	835	845	ISO 3675/ASTM D4052
Distillation T95	°C	-	370	EN-ISO 3405
Viscosity at 40°C	mm^2/s	2.5	3.5	EN-ISO 3104
Sulfur content	% mass	0.1	0.2	ISO 8754, EN 24260

Stage III A: Sulfur: max 300 ppm

Stage III B and IV: Sulfur: max 10 ppm

Market diesel fuel for NRMM applications: Dir 98/70 amendment adopted by EU Parliament on 17 Dec 08 (to be endorsed by EU Council)

Sulfur max 1000 ppm from 01 Jan 08

Sulfur max 10 ppm from 01 Jan 11

Possible derogation: Sulfur 1000 ppm until 31 Dec 11

Sulfur 20 ppm from Jan 11

NRMM EU Gasoline Reference Fuel (CEC RF-75-T-96)

Parameter	Unit	Stage I/II		Test Method
		Min	Max	
RON	-	95	-	EN 25164
MON	-	85	-	EN 25163
Density at 15°C	kg/m^3	748	762	ISO 3675
RVP	kPa	56.0	60.0	EN 12
Sulfur	ppm	-	100	EN-ISO 14596
IBP	°C	24	40	EN-ISO 3405
Distillation at 100°C	% vol	49.0	57.0	EN-ISO 3405
Distillation at 150°C	% vol	81.0	87.0	EN-ISO 3405
FBP	°C	190	215	EN-ISO 3405

The fuel for 2-stroke engines is a blend of lubricant oil and petrol

REFERENCE FUELS US

EPA / CARB – Certification Diesel Reference Fuel

Fuel Property	Unit	1994-2006 MY vehicles		2007 and later MY vehicles			Test [1]
		Federal	California	Federal specifications		California Specifications	
				1-D [2]	2-D		
Cetane Number (natural)	-	42-50	47-55	40-54	40-50	47-55	D-613
Distillation Range	°F (°C)						D-86; 13 CCR section 2282 (g) (3)
Initial Boiling Point		340-400 (171-204)	340-420 (171-216)	330-390 (166-199)	340-400 (171-204)	340-420 (171-216)	
10% Point		400-460 (204-238)	400-490 (204-254)	370-430 (188-221)	400-460 (204-238)	400-490 (204-254)	
50% Point		470-540 (243-282)	470-560 (243-293)	410-480 (210-249)	470-540 (243-282)	470-560 (243-293)	
90% Point		560-630 (293-332)	550-610 (288-321)	460-520 (238-271)	560-630 (293-332)	550-610 (288-321)	
End Point		610-690 (321-366)	580-660 (304-349)	500-560 (260-293)	610-690 (321-366)	580-660 (304-349)	
API Gravity	-	32-37	33-39	40-44	32-37	33-39	D-287
Total Sulfur	ppm (wt)	0.03-0.05 % wt	0.01-0.05 % wt	7-15	7-15	7-15	D-2622; 13 CCR section 2282 (g) (3)
Nitrogen Content (max.)	ppm (wt)	-	100-500	-	-	100-500	13 CCR section 2282 (g) (3)
Total Aromatic Hydrocarbons	% (vol)	27 (min)	8-12	8 (min) [3]	27 (min) [3]	8-12	D-1319; 13 CCR section 2282 (g) (3)
Polycyclic Aromatic Hydrocarbons	% (wt)	-	1.4 (max)	-	-	1.4 (max)	
Flashpoint (min.)	°F (°C)	130 (54)	130 (54)	120 (49)	130 (54)	130 (54)	D-93
Viscosity @ 40 °F (4°C)	Mm^2/sec	2.0-3.2	2.0-4.1	1.6-2.0	2.0-3.2	2.0-4.1	D-445

[1] ASTM standards and/of California Title 13, CCR procedures

[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] remainder shall be paraffins, naphthenes, and olefins

REFERENCE FUELS US

EPA / CARB – Diesel Reference Fuel for Non-Road Diesel Engines

Fuel Property	Unit	Emission Regulation		ASTM Test
		Tier 1-3	Tier 4	
Cetane Number (natural)		40-48	40-50	D-613
Cetane Index			40-50	D-976
Distillation Range	°F (°C)			D-86
Initial Boiling Point		340-400 (171-204)	340-400 (171-204)	
10% Point		400-460 (204-238)	400-460 (204-238)	
50% Point		470-540 (243-282)	470-540 (243-282)	
90% Point		560-630 (293-332)	560-630 (293-332)	
End Point		610-690 (321-366)	610-690 (321-366)	
API Gravity		32-37	32-37	D-287
Total Sulfur [3]	ppm (wt.)	300-4000	7-4000 [2]	D-2622
Aromatic Hydrocarbons (min.)	% (vol.)	8 (min.) [1]	27 (min.) [1]	D-5186
Flashpoint (min.)	°F (°C)	130 (54)	130 (54)	D-93
Viscosity @ 38°F (3°C)	mm^2/sec	2.0 - 3.2	2.0 - 3.2	D-445

[1] remainder shall be paraffins, naphthenes, and olefins
[2] Three fuel grades: Ultra Low Sulfur (7-15 ppm); Low Sulfur (300-500 ppm); High Sulfur (2000-4000 ppm).
[3] The general EPA position has been that the actual sulfur content in the certification fuel should reflect the fuel quality to be used in the field.

With the evolution of non-road fuel quality in the US market in mind, EPA adopted the following regulatory provisions for sulfur content in test fuels

Sulfur ≤ 2.000 ppm (0.2%) for Tier 1-3 thru MY2007
300-500 ppm sulfur for MY 2008-2010 engines
7-15 ppm sulfur for Tier 4 engines from 2011

The following provisions apply to sulfur content in certification fuels in the transitional period (2006-2010) and are at the certifying manufacturer's option;

The manufacturer must help ensure that the specified Fuel is used in the field

300-500 ppm for some MY 2006-2007 engines ≥ 100hp
7-15 ppm for MY 2007-2010 engines that use sulfur sensitive technology
7-15 ppm for MY 2008-2010 engines < 75 hp

REFERENCE FUELS US / Japan

EPA / CARB – Gasoline Reference Fuel

Parameter	Unit	EPA / CARB specs
MON/RON	-	82/87
(MON + RON) / 2, min	93	91
RVP (kPA) @ 7,8 °C[2)]	55,2-63,4	46,8- 48,3
FBP (°F)	415	390
T10 (°F)	120-135	130-150
T50 (°F)	200-230	203-220
T90 (°F)	300-325	295-330
Lead (g/l) Max	0,013	0
Sulfur (ppm) Max	1000 [1)]	30-40
Benzene (% vol) Max	-	0,8-1
Aromatics (% vol) Max	35	22-35
Olefins (% vol) Max	10	4-10

CARB Phase 3 uses ethanol as an oxygenate

[1)] EPA: Sulfur reduced to 15 - 80 ppm. 100% in 2006

[2)] RVP for altitude testing: 7.6-8.0 psi or 52-55 kPa

Japanese Diesel Reference Fuel

The properties of this fuel are similar to the JIS #2 market diesel.

Parameter	Unit	Limit		Test
		Min	Max	
Cetane Number	-	45	-	JIS K2280
Sulfur	ppm	-	50	JIS K2541
Viscosity @ 40°C	mm^2/s	2.5	-	JIS K2283
Flash Point	°C	50	-	JIS K2265
Distillation, 90% v/v rec.	°C	-	350	JIS K2254

Sulfur: 10 ppm effective from 2007

Five grades of diesel fuels: special n° 1, n° 1, n° 2, n° 3 and special n°3
Highway vehicles (PC, trucks and buses) use n° 2 diesel fuel
Special n° 3 is used in winter in cold climate areas
Most of off-road equipment use n° 2 diesel fuel
Some of them use n° 1 category (Sulfur 0.5%)

1) C.I. Engines

Euro Stage I and Stage II

Dir 97/68/EC, amended by Dir 2002/88/EC

Test cycle: NRSC (see page 77)

ISO 8178-C1 for C.I. engines operated under intermittent speed

ISO 8178-D2 for C.I. engines operated under constant speed

Cat	Net Power P (kW)	CO (g/kWh)	HC (g/kWh)	NOx (g/kWh)	PM (g/kWh)	TA	NR
Stage I (engine out emissions)							
A	130 - 560	5,0	1,3	9,2	0,54	01 Jul. 98	01 Jan. 99
B	75 - 130	5,0	1,3	9,2	0,70	01 Jul. 98 [1]	01 Jan. 99 [2]
C	37 - 75	6,5	1,3	9,2	0,85	01 Jul. 98 [1]	01 Apr. 99 [2]
Stage II [4]							
E	130 - 560	3,5	1,0	6,0	0,2	01 Jan. 01	01 Jul. 02
F	75 - 130	5,0	1,0	6,0	0,3	01 Jan. 02	01 Jul. 03
G	37 - 75	5,0	1,3	7,0	0,4	01 Jan. 03	01 Jan. 04
D	18 - 37	5,5	1,5	8,0	0,8	01 Jan. 01 [3]	01 Jan. 02 [3]

[1] 01 Jan. 01 for agricultural and forestry tractors

[2] 01 Jul. 01 for agricultural and forestry tractors

[3] 1 year later for agricultural applications and forestry tractors

[4] For constant speed engines, implementation date: 01 Jan. 07

EUROPEAN UNION

Euro Stage III and IV Dir 97/68/EC as amended by Dir 2004/26/EC and Dir 2006/105/EC

Test cycle (See pages 77-79)

NRSC: variable speed engine: Stage III A, Stage III B and Stage IV (gaseous pollutants): ISO 8178-4 C1; constant speed engines: ISO 8178-4 D2

NRTC: variable speed engines: Stage III B and Stage IV: particulate emissions (Manufacturers may elect to use for Stage III A, Stage III B and Stage IV)

Category	Net Power (kW)	CO (g/kWh)	HC (g/kWh)	NOx (g/kWh)	PM (g/kWh)	TA	NR
Stage III A [1)]							
H	130 ≤ P < 560	3.5	NOx + HC: 4.0		0.2	30 Jun. 05	31 Dec. 05
I	75 ≤ P < 130	5.0	NOx + HC: 4.0		0.3	31 Dec. 05	31 Dec. 06
J	37 ≤ P < 75	5.0	NOx + HC: 4.7		0.4	31 Dec. 06	31 Dec. 07
K	19 ≤ P < 37	5.5	NOx + HC: 7.5		0.6	31 Dec. 05	31 Dec. 06
Stage III B							
L	130 ≤ P < 560	3.5	0.19	2.0	0.025	31 Dec. 09	31 Dec. 10
M	75 ≤ P < 130	5.0	0.19	3.3	0.025	31 Dec. 10	31 Dec. 11
N	56 ≤ P < 75	5.0	0.19	3.3	0.025	31 Dec. 10	31 Dec. 11
P	37 ≤ P < 56	5.0	NOx + HC: 4.7		0.025	31 Dec. 11	31 Dec. 12
Stage IV							
Q	130 ≤ P < 560	3.5	0.19	0.4	0.025	31 Dec. 12	31 Dec. 13
R	56 ≤ P < 130	5.0	0.19	0.4	0.025	30 Sep. 13	30 Sep. 14

[1)] Other than constant speed engines

Constant speed engines implementation dates

Category	TA	NR
H	31 Dec. 09	31 Dec. 10
I	31 Dec. 09	31 Dec. 10
J	31 Dec. 10	31 Dec. 11
K	31 Dec. 09	31 Dec. 10

Deterioration Factors (DF's) and Emission Durability Period (EDP)

- Additive DF's are applied for each pollutant for C.I. engines not using any after-treatment device.
- Multiplicative DF's are applied for each pollutant for C.I. engines using an after-treatment device.

DF's are determined by manufacturers in accordance with a specific test procedure which must be representative of use and have duration of at least 1/4 EDP

EDP:

For C.I. Stage III A, III B and IV engines

Category	EDP (hours)
≤ 37 kW (constant speed engines)	3000
≤ 37 kW (not constant speed engines)	5000
> 37 kW	8000

2) Agricultural and Forestry Tractors

Dir 74/150/EC as amended by Dir 2000/25/EC and by Dir 2005/13/EC
Dir 97/68/EC, as amended by Dir 2002/88/EC and Dir 2004/26/EC
Engine categories, test cycles and emissions limits: see page 56, C.I. engines
Implementation Dates

Stage	Cat.	Engine Power EP (kw)	TA	NR
Stage I	C	130 ≤ P < 560	01 Jul. 98	01 Jul. 01
	B	75 ≤ P < 130	01 Jan. 01	01 Jul. 01
Stage II	D	18 ≤ P < 37	01 Jan. 01	01 Jan. 02
	G	37 ≤ P < 75	01 Jan. 03	01 Jan. 04
	F	75 ≤ P < 130	01 Jan. 02	01 Jul. 03
	E	130 ≤ P < 560	01 Jan. 01	01 Jul. 02
Stage III A	H, I and K	75 ≤ P < 560 19 ≤ P < 37	31 Dec. 05	H: 31 Dec. 05 I, K: 31 Dec. 06
	J	37 ≤ P < 75	31 Dec. 06	31 Dec. 07
Stage III B	L	130 ≤ P < 560	31 Dec. 09	31 Dec. 10
	M and N	56 ≤ P < 130	31 Dec. 10	31 Dec. 11
	P	37 ≤ P < 56	31 Dec. 11	31 Dec. 12
Stage IV	Q	130 ≤ P < 560	31 Dec. 12	31 Dec. 13
	R	56 ≤ P < 130	31 Dec. 13	30 Sep. 14

NB: For engines of categories H to R, the NR dates can be postponed for 2 years for engines with production dates prior to the said date.

Opacity for Exhaust Gases

Dir 77/537/EEC as amended by Dir 97/54/EC

Application: tractors equipped with wheels or endless tracks, having at least 2 axles and with 6 km/h < max design speed ≤ 40 km/h

Two tests are required:

1) Test at steady speed

   6 measurements shall be made at engine speeds spaced out uniformly between that corresponding to max power and the higher of the following two engine speeds: 55% of the engine speed corresponding to the maximum power and 1000 rpm The engine shall be running under 80% of the maximum load. The light absorption coefficient of the exhaust gases shall be measured with an opacimeter. For each measuring point, the smoke measured should not exceed the limit values (SL) specified in the directive, which are a function of the air flow rate. The value selected will be measured (SM) nearest the relevant limit value.

2) Test under free acceleration

   With warm engine from the idle to maximum speed giving an average (XM) of 4 consecutive non-dispersed values.

   The free acceleration smoke limit is the lower of the two values calculated below

   XL1= (SL/SM) * XM and XL2 = XM + 0,5

Amendment proposal to Dir 2000/25/EC and Dir 2005/13/EC

- Stage IIIB and IV implementation should be delayed by 5 years for tractors of categories T2, C2 and T4.1

  Justification for delay to be reviewed by 31 Jan 12

  T2: wheeled tractor w/ min track width < 1150 mm, unladen mass > 600 kg and ground clearance ≤ 600 mm

  C2: track laying tractor equivalent to T2

  T4.1: high clearance tractor (vineyard tractor)

- Scope extension to all categories of tractors, trailers and towed machinery

Medium duty. Advanced design. Robust performance.

Delphi's Multec® Medium Duty Diesel Common Rail System offers impressive simplification of fuel and control systems and up to 2,000 bar system pressure capability. Its solenoid injector technology is designed to deliver precise fuel quantities over the life of the engine for cost effective, robust emissions and acoustics performance. The Delphi Multec® Medium Duty Common Rail System is ideally suited for one- to six-cylinder medium duty truck and off-highway programs.

To find out more, visit:
www.delphi.com/manufacturers/cv/powertrain/md_dcr/

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3) SI Engines

Dir 2002/88/EC is amending Dir 97/68/EC by extending its scope to small spark ignition engines (≤ 19kW).

Classification

Main Class S: small engines with a net power ≤ 19 kW			
SH		SN	
Engines for handheld machinery		Engines for non handheld machinery	
Category	Displacement (cc)	Category	Displacement (cc)
SH: 1	< 20	SN: 1	< 66
SH: 2	20 ≤ D < 50	SN: 2	66 ≤ D < 100
SH: 3	≥ 50	SN: 3	100 ≤ D < 225
		SN: 4	≥ 225

Test cycles (See pages 77-79)

ISO 8178-4 to be applied

Cycle D: engines with constant speed and intermittent load

Cycle G1: non-handheld intermediate speed machinery

Cycle G2: non-handheld rated speed machinery

Cycle G3: handheld machinery

Emissions Limits

	Stage I				Stage II		
Engine Class	CO	HC	NOx	TA	CO	HC+NOx	TA
	(g/kWh)				(g/kWh)		
SH: 1	805	295	5.36	11 Aug. 04	805	50	01 Aug. 07
SH: 2	805	241	5.36	11 Aug. 04	805	50	01 Aug. 07
SH: 3	603	161	5.36	11 Aug. 04	603	72	01 Aug. 08
SN: 1	519	HC + NOx = 50		11 Aug. 04	610	50	01 Aug. 04
SN: 2	519	HC + NOx = 40		11 Aug. 04	610	40	01 Aug. 04
SN: 3	519	HC + NOx = 16.1		11 Aug. 04	610	16.1	01 Aug. 07
SN: 4	519	HC + NOx = 13.4		11 Aug. 04	610	12.1	01 Aug. 06

Max limit NOx (Stage II) for all engines: 10g/kWh

Stage III and IV: see page 56 (C.I. Stage III/IV)

Emission Durability Period (EDP) and Deterioration Factors (DF's)

1) DF's

Manufacturers can get an assigned DF or calculate a DF, for each regulated pollutant for all stage 2 engine families. These DF's will be used for TA and COP testing.

2) EDP (in hours)

EDP category shall be the category which most closely approaches the expected useful lives of the equipment into which the engines will be installed.

Engine Class	1	2	3
SH: 1	50	125	300
SH: 2	50	125	300
SH: 3	50	125	300
SN: 1	50	125	300
SN: 2	125	250	500
SN: 3	125	250	500
SN: 4	250	500	1000

Amendment proposal to NRMM Directive under discussion

- Exemptions in stage II for top handle machine tree service chainsaw and hand-held hedge trimmer until 01 Aug 14
- Test cycles: Stage I, II, IIIA: NRSC only
  Stage IIIB, IV: NRSC and NRTC
- Test procedure including cold/hot composite test sequence
- NOx control: keep NOx emissions within desirable limits
  2 different proposals (stage IIIB and stage IV)
  Experience based on HD directive (see pages 11 and 41)
  Technology neutral
- Definition of reference speed for NRTC speed denormalisation and NRSC 8-mode test
- Remaining issues for further discussions:
  + Recital to UN-ECE NRMM-GTR (control area, reference fuel properties...)
  + Defeat device and cycle by-pass provisions
  + Deterioration factors; aftertreatment adjustment factors
  + Regularisation of field test practices
  + Test cycle and emission limits for engines > 560 kW
  + Cold/hot start weight factors
  + Alternative type approval provisions

Off-Road C.I. engines

40 CFR part 89, covering mobile non road diesel engines, used in construction, agricultural and industrial applications.

US Non-Road regulations are in the imperial system of units, all standards expressed in g/bhp.h (metric equivalent are shown in brackets).

EPA 96 – Tier 1 Initial schedule

Applied to engines between 175 bhp (130 kW) and 750 bhp (560 kW).

Other engine categories have been added later. Test cycle: ISO 8178

Engine Power		Model	NOx	HC	CO	PM
hp	kW	Year	g/bhp.h (g/kWh)			
175 ≤ hp < 750	130 ≤ P < 560	1996	6.9 (9.2)	1.0 (1.3)	8.5	0.40
100 ≤ hp < 175	75 ≤ P < 130	1997	6.9 (9.2)	-	-	-
50 ≤ hp < 100	37 ≤ P < 75	1998	6.9 (9.2)	-	-	-
hp ≥ 750	P ≥ 560	2000	6.9 (9.2)	1.0 (1.3)	8.5	0.40

Smoke: 40 CFR part 86 specifies opacity test measurements w/ limit values

A (acceleration): 20% opacity; B (lugging mode): 15%; C (Peak): 50%

EPA 98 - Final rule – Tier 1 – Tier 2 – Tier 3

Broadly similar to EU standards

Tier	Engine Power		Model	g/bhp.h (g/kWh)			
	HP	kW	Year	NMHC+NOx	NOx	CO	PM
1	< 11	< 8	2000	7.8 (10.5)	-	6.0 (8.0)	0.75 (1.0)
2			2005	5.6 (7.5)	-	6.0 (8.0)	0.6 (0.8)
4			2008-14	5.6 (7.5)	-	6.0 (8.0)	0.3 (0.4) [1]
1	11-25	8-19	2000	7.1 (9.5)	-	4.9 (6.6)	0.6 (0.8)
2			2005	5.6 (7.5)	-	6.0 (8.0)	0.6 (0.8)
4			2008-14	5.6 (7.5)	-	6.0 (8.0)	0.3 (0.4)
1	25-50	19-37	1999	7.1 (9.5)	-	4.1 (5.5)	0.6 (0.8)
2			2004	5.6 (7.5)	-	4.1 (5.5)	0.45 (0.6)
Interim 4			2008-12	5.6 (7.5)	-	4.1 (5.5)	0.22 (0.3)
Final 4			2013-14	3.5 (4.7)	-	4.1 (5.5)	0.22 (0.3)
1	50-75	37-56	1998	-	-	6.9 (9.2)	-
2			2004	5.6 (7.5)	-	3.7 (5.0)	0.3 (0.4)
Interim 4			2008-12	3.5 (4.7)	-	3.7 (5.0)	0.22 (0.3) [2]
Final 4			2013-14	3.5 (4.7)	-	3.7 (5.0)	0.02 (0.03) [2]
1	75-100	56-75	1998	-	6.9 (9.2)	-	-
2			2004	5.6 (7.5)	-	3.7 (5.0)	0.3 (0.4)
3			2008	3.5 (4.7)	-	3.7 (5.0)	0.3 (0.4)
Interim 4			2012-14	2.64 (3.54)	2.5 (3.35)	3.7 (5.0)	0.015 (0.20) [3]
1	100-175	56-130	1997	-	6.9 (9.2)	-	-
2			2003	4.9 (6.6)	-	3.7 (5.0)	0.22 (0.3)
3			2007	3.0 (4.0)	-	3.7 (5.0)	0.22 (0.3)
Interim 4			2012-14	2.64 (3.54)	2.5 (3.35)	3.7 (5.0)	0.015 (0.20) [3]

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Tier	Engine Power		Model	g/bhp.h (g/kWh)			
	HP	kW	Year	NMHC+NOx	NOx	CO	PM
1	175-300	130-225	1996	7.9 (10.6)	6.9 (9.2)	8.5 (11.4)	0.40 (0.54)
2			2003	4.9 (6.6)	-	2.6 (3.5)	0.15 (0.20)
3			2006	3.0 (4.0)	-	2.6 (3.5)	0.15 (0.20)[4]
Interim 4			2011-13	1.64 (2.20)	1.5 (2.0)	2.6 (3.5)	0.15 (0.20)[3]
Final 4			2014	0.44 (0.59)	0.3 (0.4)	2.2 (2.95)	0.15 (0.20)
1	300-600	225-450	1996	7.9 (10.6)	6.9 (9.2)	8.5 (11.4)	0.40 (0.54)
2			2001	4.9 (6.6)	-	2.6 (3.5)	0.15 (0.20)
3			2006	3.0 (4.0)	-	2.6 (3.5)	0.15 (0.20)[4]
Interim 4			2011-13	1.64 (2.20)	1.5 (2.0)	2.6 (3.5)	0.15 (0.20)[3]
Final 4			2014	0.44 (0.59)	0.3 (0.4)	2.2 (2.95)	0.15 (0.20)
1	600-750	450-560	1996	7.9 (10.6)	6.9 (9.2)	8.5 (11.4)	0.40 (0.54)
2			2002	4.8 (6.4)	-	2.6 (3.5)	0.15 (0.20)
3			2006	3.0 (4.0)	-	2.6 (3.5)	0.15 (0.20)[4]
Interim 4			2011-13	1.64 (2.20)	1.5 (2.0)	2.6 (3.5)	0.15 (0.20)[3]
Final 4			2014	0.44 (0.59)	0.3 (0.4)	2.2 (2.95)	0.15 (0.20)
1	> 750[5]	> 560	2000	7.9 (10.6)	6.9 (9.2)	8.5 (11.4)	0.40 (0.54)
2			2006	4.8 (6.4)	-	2.6 (3.5)	0.15 (0.20
Interim 4			2011-14	2.9 (3.9)	2.6 (3.5)	2.6 (3.5)	0.07 (0.09)
1	750-1200[6]	560-895	2000	7.9 (10.6)	6.9 (9.2)	8.5 (11.4)	0.40 (0.54)
2			2006	4.8 (6.4)	-	2.6 (3.5)	0.15 (0.20)
Interim 4			2011-14	2.9 (3.9)	2.6 (3.5)	2.6 (3.5)	0.07 (0.09)
1	>1200[6]	> 895	2000	7.9 (10.6)	6.9 (9.2)	8.5 (11.4)	0.40 (0.54)
2			2006	4.8 (6.4)	-	2.6 (3.5)	0.15 (0.20)
Interim 4			2011-14	0.8 (1.07)	0.5 (0.67)	2.6 (3.5)	0.07 (0.09)

1) The PM std for hand-start, air-cooled, direct-injection engines below 11 hp may Be delayed until 2010 and be set at 0.45 g/bhp-hr
2) Engine families in this power category may alternately meet Tier 3 PM stds (0.30 g/bhp-hr) from 2008-2011 in exchange for introducing final PM stds in 2012
3) The implementation schedule shown is the 3 year alternate NOx approach. Other schedules are available
4) Certain manufacturers have agreed to comply with these stds by 2005
5) Mobile machines only
6) Generators only

EPA 98 did not establish Tier 3 PM emissions – Tier 2 PM limits carry over
Also included: averaging, banking and trading (ABT) of emission credits and NTE "Family Emissions limits" (FEL) for emission averaging.
Amended requirements in Sep. 07 to allow Tier 3 phase-in relief in exchange for equivalent loss of Tier 4 flexibility

Federal smoke test (40 CFR part 86, sub part I)
Harmonized smoke test: ISO 8178-9
A (acceleration) = 20% opacity B (lugging Mode) = 15% opacity
C (Peak) = 50% opacity

Engine useful life
The emissions standards must be met over the entire useful life of the engine.
DF's are applicable to all engines.

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Power Rating	Rated engine speed	Useful life		Recall Testing period	
		Hours	Years	Hours	Years
< 25 hp (< 19 kW)	all	3000	5	2250	4
25 - 50 hp (19-37 kW)	Constant speed engine ≥ 3000 rpm	3000	5	2250	4
	all others	5000	7	3750	5
> 50 hp (> 37 kW)	all	8000	10	6000	7

Blue Sky Series

Manufacturers can voluntary use more stringent emission standards to earn a designation “Blue Sky Series” engines. This is applicable to Tier 1-3 certifications, MY 2004. Blue Sky program eliminated in Tier 4 regulations

Engine Power		NMHC + NOx	PM
hp	kW	g/bhp-h (g/kWh)	g/bhp-h (g/kWh)
< 11	< 8	3.4 (4.6)	0.36 (0.48)
11 - 25	8 - 19	3.4 (4.6)	0.36 (0.48)
25 - 50	19 - 37	3.4 (4.6)	0.27 (0.36)
50 - 100	37 - 75	3.5 (4.7)	0.18 (0.24)
100 - 175	75 - 130	3.0 (4.0)	0.13 (0.18)
175 - 750	130 - 560	3.0 (4.0)	0.09 (0.12)
≥ 750	≥ 560	2.8 (3.8)	0.09 (0.12)

Land-based non-road diesel engines (40 CFR part 89.112) and land-based non-road SI engines > 25 hp (40 CFR part 1048.140)

Tier 4 (40 CFR Part 1039)

Application after all the transition and phase-in provisions expire, after MY 2014

Some of these standards also apply for 2014 and earlier MY.					
See below: interim Tier 4					
Max Engine Power (kW)	**PM**	**NOx**	**NMHC**	**NOx+NMHC**	**CO**
	(g/kWh)				
< 19	0.40 [1]	-	-	7.5	6.6 [2]
19 - 56	0.03	-	-	4.7	5.0 [3]
56 - 130	0.02	0.40	0.19	-	5.0
130 - 560	0.02	0.40	0.19	-	3.5
> 560 (generator sets)	0.03	0.67	0.19	-	3.5
> 560 (all except generator sets)	0.04	3.5	0.19	-	3.5

[1] Optional PM standard EP< 8kW: hand-startable, air cooled and DI engines: 0.60g/kWh in 2010, before Tier 2 limits are required

[2] EP < 8kW: CO: 8.0 g/kWh [3] EP < 37kW: CO: 5.5 g/kWh

Useful Life: No change from Tier 3

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Transition and phase-in provisions

1) EP < 19kW

Max Engine Power	MY	PM	NOx+NMHC	CO
		g/kWh		
EP < 8kW	2008-2014	0.40 [1)]	7.5	8.0
8 ≤ EP < 19	2008-2014	0.40	7.5	6.6

[1)] For hand-startable, air cooled and DI engines: possible delay until 2010 (0.60 g/kWh). For MY 2009 and earlier: Tier 2 standards applicable.

2) 19 ≤ EP < 37

MY	PM	NOx+NMHC	CO
	g/kWh		
2008-2012	0.30	7.5	5.5
2013-2014	0.03	4.7	5.5

3) 37 ≤ EP < 56

Option [1)]	MY	PM	NOx+NMHC	CO
		g/kWh		
# 1	2008-2012	0.30	4.7	5.0
# 2	2012	0.03	4.7	5.0
All	2013-2014	0.03	4.7	5.0

[1)] All engines ≥ 37 kW and < 56 kW, < 2013MY, must meet option #1.

Under option #2, all engines ≥ 37 kW and < 56 kW, MY 2012, must meet Tier 4

4) 56 ≤ EP< 130

MY [1)]	Phase-in option	PM	NOx	NMHC	NOx+NMHC	CO
		g/kWh				
2012	Phase in (#1)	0.02	2.3	0.19	-	5.0
2013	Phase in (#2)	0.02	3.4	0.19	4.0 [2)]	5.0
2014	All engines	0.02	0.40	0.19	-	5.0

[1)] PM/CO: full compliance from 2012 [2)] NOx + NMHC for 56 ≤ EP < 75 limit is 4.7 g/kWh

NOx/HC:

- option 1 (if banked Tier 2 credits used): 50% engines must comply in 2012-2013
- option 2 (if no Tier 2 credits claimed): 25% engines must comply in 2012-2014
  Full compliance from 31 Dec. 2014

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5) 130 ≤ EP < 560

MY [1]	Phase-in option	PM	NOx	NMHC	NOx+NMHC	CO
		g/kWh				
2011-2013	Phase in	0.02	2.0	0.19	-	3.5
	Phase out	0.02	-	-	4.0	3.5
2014	All engines	0.02	0.40	0.19	-	3.5

[1] PM/CO: full compliance from 2011; NOx/HC: 50% engines must comply in 2011-2013

6) EP > 560

MY	Phase-in option		PM	NOx	NMHC	CO
			g/kWh			
2011 -2014	560 < kW ≤ 900	All	0.10	3.5	0.40	3.5
	kW > 900	Generators sets	0,10	0,67	0,40	3,5
	kW > 900	All except generator sets	0.10	3.5	0.40	3.5

Smoke test: no change from Tier 3

No smoke test required for engines certified to PM ≤ 0.07g/kWh

No closed crankcase ventilation required if the open crankcase emissions are added to exhaust emissions.

Tier 4 includes provisions as ABT and FEL as well.

Tier 4 test cycles (See pages 77-79)

Steady-state test cycle: ISO 8178

Transient test

Tier 4 standards have to be met on both NRSC and NRTC cycles

NRTC required from 2011 for engines 130-560kW
2012 for engines 56-130kW
2013 for engines < 56kW

Cold start emissions are weighted at 5% and hot start emissions at 95% for the final result.

NTE Standards

Measured without any specific test schedule.

Effective in 2011 for engines > 130 kW
2012 for engines 56-130 kW
2013 for engines < 56 kW

NTE limits are set at 1,25 times the regular standard for each pollutant.

Exceptions: if NOx < 2.5 g/kWh or PM < 0.07 g/kWh, NTE multiplier is 1,5

NTE standards apply on certification of engines and useful life of the engine.

NTE purpose is to prevent the use of defeat devices.

Off-Road S.I. engines

S.I. engines ≤ 19kW (CFR 40, Parts 90 and 91)

Engine classes

Class	Category	Engine Displacement
I	Non-handheld	100 to < 225 cc
I-A	Non-handheld	< 66 cc
I-B	Non-handheld	66 to < 100 cc
II	Non-handheld	≥ 225 cc
III	Handheld	< 20 cc
IV	Handheld	20 to < 50 cc
V	Handheld	≥ 50 cc

Phase 1 standards (MY 1997)

Class		Eng. Displ (CC)	HC+NOx	HC	CO	NOx
			g/kWh			
I	NH	< 225	16.1	-	519	-
II	NH	≥ 225	13.4	-	519	-
III	H	< 20	-	295	805	5.36
IV	H	≥ 20, < 50	-	241	805	5.36
V	H	≥ 50	-	161	603	5.36

Phase II Standards

Eng Class	HC+NOx	NMHC+NOx (NG engine)	CO	Effective Date
I	16.1	14.8	610	01 Aug. 07 [1)]
I-A	50	N/A	610	MY 2001
I-B	40	37	610	MY 2001

[1)] also incl. any Class I eng family produced ≥ 01 Aug 03 before introd. into commerce

Class II	Emissions	2001	2002	2003	2004	2005, +
	HC+NOx	18.0	16.6	15.0	13.6	12.1
	NMHC+NOx	16.7	15.3	14.0	12.7	11.3
	CO	610	610	610	610	610

Eng Class	Emission (g/kWh)	2002	2003	2004	2005	2006	2007
III	HC + NOx	238	175	113	50	50	50
	CO	805	805	805	805	805	805
IV	HC + NOx	196	148	99	50	50	50
	CO	805	805	805	805	805	805
V	HC + NOx	-	-	143	119	96	72
	CO	-	-	603	603	603	603

US FEDERAL

Test procedure: SAE J1088 cycles A, B and C

Cycle A: non handheld engines to operate at an intermediate speed
Similar to ISO 8178-G1

Cycle B: non handheld engines to operate at rated speed
Similar to ISO 8178-G2

Cycle C: Handheld engines
Similar to ISO 8178-G3 except weighting Mode 1: 85% and Mode 2: 15%

Useful Life categories for phase 2 engines

Emissions must be met throughout the engine useful life. Engine manufacturers have to select the most representative category of in-use operating periods in hours for the majority of engines in the engine family

Class	Category C	Category B	Category A
NH-IA	50	125	300
NH-IB / NH-I	125	250	500
NH-II	250	500	1000
H-III / H-IV / H-V	50	125	300

ABT Program: Phase II handheld engines and Class I-A and I-B non handheld engines have to fulfil a certification, averaging, banking & trading program.
Non-hand Held engines < 1.0 liter and > 25 Hp: useful life 1000 hrs

Large S.I. engines (harmonized w/ CARB thru MY2009)

40 CFR Part 1048

Includes non road equipment such as forklift, sweeper, pump and generator.

Standards	MY	Testing Type	Emission [1] Standards		Alternate em. Stand. For serve duty engines	
			HC+NOx	CO	HC+NOx	CO
Tier 1	2004	Duty cycle [2]	4.0	50.0	4.0	130
	-2006	Field testing	5.4	50.0	5.4	130
Tier 2	2007	Duty cycle [2]	2.7	4.4	2.7	130
		Field testing	3.8	6.5	3.8	200

[1] Alternative according to the following formula: $(HC+NOx) \times (CO)^{0.784} \leq 8{,}57$
Field testing limits use: $(HC+NOx) \times (CO)^{0.791} \leq 16.78$

[2] Tier 1: steady state cycle. Tier 2: steady state + transient cycles

Useful life period: 7 years or 5000 operating hours, severe duty 7 yr / 1500 hrs

Blue Sky series emissions standards

MY 2003, when meeting 2004 requirements
MY 2003-2006, when meeting 2007 requirements
In addition:
HC+NOx ≤ 0.08 g/kWh and CO ≤ 4.4 g/kWh (steady-state and transient tests)
HC+NOx ≤ 1.1 g/kWh and CO ≤ 6.6 g/kWh (field test)

Test procedure

MY 2004-2006: ISO 8178-4 C2, D2
MY 2007: additional requirements: a/ warm up segment
b/ transient segment
c/ steady state segment

Other requirements

Warranty: minimum 1st half of engine's useful life or 3 years.
Diagnostic system: from MY 2007
Monitoring area: air-fuel ratio maintained at λ 1 if control system depends on $\lambda = 1$
emission control system malfunction

Evaporative emissions: from MY 2007
- 0.2g/gallon of fuel tank capacity for engines > 1L (3 days loss, 72-96 F temperature cycling)
- Design based certification possible

Manufacturers required to perform In-Use testing:
- test min of 4 engines in 25% of engine families
- small engine families (< 500 eng) require min of 2 engines tested
- if manufacturer's total production < 2000, min testing is 2 engines

Recreational vehicles engines

Off highway Motorcycles

MY	Emission standards (g/km)		Phase-in	Max allowable Family Emission limits (g/km)	
2006	2.0	25.0	50%	20.0	50
2007	2.0	25.0	100%	20.0	50

Useful life: ≥ 70 cc:10 000km or 5 years; < 70 cc: 5 000 km or 5 years

All terrain vehicles (ATVs) and off road utility vehicles

MY	Emission standards (g/km)		Phase-in	Max allowable Family Emission limits (g/km)	
	HC+NOx	CO		HC+NOx	CO
2006	1.5	35.0	50%	20.0	-
2007, +	1.5	35.0	100%	20.0	-

Useful life: ≥ 100 cc: 1000 hrs of engine operation or 5 years
< 100 cc: 500 hrs of engine operation or 5 years

Evaporative emissions standards

From MY 2008, max permeation emissions for fuel tank: 1.5 g/m^2/day
max permeation emissions for fuel lines: 15 g/m^2/day

Snowmobiles: (Emissions standards in g/kWh)

Phase 1: HC: 100; CO: 275: Phase in 50% MY 2006; 100% MY 2007-2009
Phase 2: HC: 75; CO: 275: Phase in 100% MY 2010-2011
Phase 3: HC: 75; CO: 200: Phase in 100% MY 2012, →
Max allowable family emission: HC: 150; HC+NOx: 165; CO:400
Phase in 100%, MY 2012, →

Useful life: min 8,000 km, 400 hrs of engine operation or 5 years

Test cycles

Highway motorcycle test cycle: similar to FTP75
For MY 2006-2008: alternative J1088 California off - highway
Snowmobiles: SAE 982017
All terrain vehicles (ATVs)

- Same transient chassis based FTP test used for Class I motorcycles
- Optional steady-state, engine-based, test (J1088) available thru MY2013
- FTP must be used for certification of >50% of manufacturer's vol. in MY2014
- FTP must be used for certification of 100% of manufacturer's vol. in MY2015

1) Diesel C.I. engines

New vehicles

CCR, Title 13, Division 3, Chapter 9, Article 4

Similar to US-EPA regulations

Regulation applies to all diesel cycle engines in the given power categories used for agricultural, forestry, constructional and industrial applications.

In-Use provisions

Core regulations adopted, some secondary modifications pending

Applies to mobile equipment >25 hp

Sets fleet average NOx and PM standards

Large (>5000hp total hp) fleets required beginning in CY2010 to:

- Meet declining PM standards each year or apply highest level verified diesel emission control system to 20% of its horsepower.
- Meet declining NOx standards each year or repower/replace a certain portion of their fleet with new equipment

Medium (2501-5000 total hp) must meet the same requirements beginning in CY2013.

Small fleets must meet the PM requirements beginning in CY2015.

Special provisions exist for newer equip., low-use veh., small bus. credit prog.

Surplus Off-road Opt-in for NOx (SOON) program for air districts to require additional NOx reductions for certain large fleets

2) Small off-road SI engines ≤ 19kW (SORE)

CARB standards are based on:

Engine displacement (no handheld/non-handheld categories) for tailpipe emis

Category limit 65cc

Vertical and horizontal crankshaft engine classifications

Test procedures

SAE J1088: cycle A: engine > 65 cc configured for intermediate speed
cycle B: engine > 65 cc configured for rated speed
cycle C: engine > 65 cc

Similar to ISO 8178 G1, G2, G3

No SORE may be equipped w/ a defeat device

CALIFORNIA

MY	Engine Class	HC+NOx	CO	PM	Durability
		g/kWh (g/bhph)			period (hours)
2000 - 2001	≤ 65 cc	72 (54)	536 (400)	2.0 (1.5) [1]	50/125/300
	> 65 cc to < 225 cc	16.1 (12.0)	467 (350)	-	-
	≥ 225 cc	13.4 (10.0)	467 (350)	-	-
2002 - 2004	≤ 65 cc	72 (54)	536 (400)	2.0 (1.5) [1]	50/125/300
	> 65 cc to < 225 cc h	16.1 (12.0)	549 (410)	-	125/250/500
	> 65 cc to < 225 cc v	16.1 (12.0)	467 (350)	-	-
	≥ 225 cc	12.0 (9.0)	549 (410)	-	125/250/500
2005-2013+	< 50 cc	50 (37)	536 (400)	2.0 (1.5) [1]	50/125/300
	≥ 50 to ≤ 80 cc	72 (54)	536 (400)	2.0 (1.5) [1]	50/125/300
2005	> 80 to < 225 cc h	16.1 (12.0)	549 (410)	-	125/250/500
	> 80 to < 225 cc v	16.1 (12.0)	467 (350)	-	-
	≥ 225 cc	12.1 (9.0)	549 (410)	-	125/250/500
2006	> 80 to < 225 cc	16.1 (12.0)	549 (410)	-	125/250/500
	≥ 225 cc	12.1 (9.0)	549 (410)	-	125/250/500
2007	> 80 to < 225 cc	10.0 (7.5)	549 (410)	-	125/250/500
	≥ 225 cc	12.1 (9.0)	549 (410)	-	125/250/500
2008-2013+	> 80 to < 225 cc	10.0 (7.5)	549 (410)	-	125/250/500
	≥ 225 cc	8.0 (6.0)	549 (410)	-	125/250/500/1000

[1] HC+NOx, CO and PM stds applicable to all diesel; PM stds not applicable so SI eng but to all 2 stroke engine

Low-emitting Blue Sky Series engine requirements Voluntary Emission Standards (g/kWh)

MY	Engine Displacement	HC+NOx	CO	PM
2005, +	< 50 cc	25	536	2.0
	≥ 50, ≤ 80 cc	36	536	2.0
2007, +	> 80, < 225 cc	5.0	549	-
2008, +	> 225 cc	4.0	549	-

Evaporative Emission requirements

Eng. Displacement	MY	1 day diurnal g HC/day	Fuel Hose ROg/m²/day	Fuel Tank ROg/m²/day	Carbon canister
≤ 80 cc, handheld	2007-2013+			2.0	TP902
> 80 to < 225 cc Walk behind Mowers	2006	-	-	-	-
	2007-2008	1.3	-	-	-
	2009-2013+	1.0	-	-	-
> 80 to < 225 cc Others	2006	-	15	-	-
	2007-2011	1.20+0.056 tank vol (l)	15	2.5	TP902
	2012-2013+	0.95+0.056 tank vol (l)	15	1.5	TP902
≥ 225 cc	2006-2007	-	15	-	TP902
	2008-2012	1.20+0.056 tank vol (l)	15	2.5	TP902
	2013+	1.20+0.056 tank vol (l)	15	1.5	TP902

Small production vol. exempted from diurnal and fuel tank permeation stds; low permeation fuel hoses and carbon canister required from MY 2010

3) Off-road Large S.I. engines

Applied to S.I. engines ≥ 19kW (25hp), except construction and farm equipment engines < 175hp, off-road motorcycle, all terrain vehicles, snowmobiles.

Test procedure:

ISO 8178-4 C2 all the engines except:

- Generator or constant speed applications: ISO 8178-4 D2
- Engines w/ characteristics similar to SORE (< 25hp): G1

Engine Displacement	MY	HC+NOx	CO	Durability Period
		g/kWh		
≤ 1.0 l Steady state	2002-2010 +	12.0	54.9	1000 hrs or 2 years
> 1.0 liter				
Steady-state	2001-2003 [1]	4.0	49.6	-
testing	2004-2006	4.0	49.6	3500 hrs or 5 years
	2007-2009 [2]	2.7	4.4	5000 hrs or 7 years
	2010 +	0.8	20.6	5000 hrs or 7 years
> 1.0 liter	2007-2009 [2]	2.7	4.4	5000 hrs or 7 years
Transient testing	2010+	0.8	20.6	5000 hrs or 7 years
> 1.0 l Field testing	2007-2010+ [3]	3.8	6.5	5000 hrs or 7 years

[1] 2001: min 25% sales; 2002 min 50% sales; 2003: min 75% sales

ABT credits may be generated. No crankcase emissions from MY 2004.

Evaporative Emission Requirements

- HC emis. < 0.2 g/gal
- Non-metallic fuel lines must be made from Cat. 1 materials as def'd in SAE J2260

Liquid fuel in tank must not boil when machinery is operated in 30deg C ambient

Large SI Engine Fleet Average Emission Level Standard: HC+NOx (g/kW-hr)

Fleet Type	Jan. 1, 2009	Jan. 1, 2011	Jan. 1, 2013
Large Forklift	3.2 (2.4)	2.3 (1.7)	1.5 (1.1)
Medium Forklift	3.5 (2.6)	2.7 (2.0)	1.9 (1.4)
Non-Forklift	4.0 (3.0)	3.6 (2.7)	3.4 (2.5)

- Provisions exist for some rental equip., agricultural equip., limited use equip. etc.
- Warranty period: shorter of 3 yr or 2,500 hr OR 3yrs if no usage meter
- Fleet operator administered in-use compliance program

[2] MY 2007-2009: alternative certification possible.: $(HC+NOx) \times CO^{0.784} \leq 8.57$

[3] From 2007, alternate emission std: $(HC+NOx) \times CO^{0.791} \leq 16.78$

4) Off-highway recreational equipment vehicles

Motorcycles and ATV`s

Engine category	Implementation date	CO (g/km)	HC [1] (g/km)
> 90cc	1997	15.0	1.2
< 90 cc	1999	15.0	1.2

[1] corporate average standards

Optional Engine Certification Based Standards (g/km)

Engine Category	Implementation date	HC + NOx [1]	CO
ATV's < 225 CC	1997	16.1	400
ATV's ≥ 225 CC	1997	13.4	400
ORSV / ORUV	2007	12	400
SAND CARS	2007	13.4	400

[1] corporate average standards

Off-road Sport Vehicles and Off-road Utility Vehicles

Engine Category	Certification Method	CO (g/km)	HC [1] (g/km)
ORSV / ORUV	Chassis	15.0	1.2
Sand Car	Chassis	15.0	1.2

[1] corporate average standards

Test procedure:
Off-road motorcycles and AZTVs and Sand cars
Engines > 170cc: FTP 75
Engines ≤ 170cc: modified FTP 75
Useful life is 5 years or 10,000 km for all apllications

Evaporative Requirements

Engine Category	HC (g/m²/day)	Temperature
Tank	1.5	28°C
Hose	15.0	23°C

Design based certification available

JAPAN

Diesel powered special vehicles (off-highway)

1) Construction equipment (Ministry of Land, Infrastructure and Transport)
   First phase (1996-1998) similar to Euro Stage I, US Tier 1.
   Second phase (Oct. 2003) similar to Euro Stage II, US Tier 2, Ministry of Environment procedure.
   Additional Requirements:
   8 kW ≤ P < 19 kW: NOx: 9 g/kWh; HC: 1.5 g/kWh; CO: 5.0 g/kWh; PM: 0.80 g/kWh; smoke: 40%
2) Ministry of Environment
   Tests are made accordingly to ISO 8178.
   Application: diesel off-road vehicles w/ engines w/ a rated output between 19 kW and 560 kW
   2006+ standards are similar in stringency to US Tier 3 and EU Stage III A but are not harmonized w/ US or EU regulations
   Proposal for construction, farm and other off-road vehicles (> 56 kW or 75 hp)
   NOx to be reduced by 90% in 2015; phase-in starting 2009
   PM to be reduced by 88% in 2011, 93% in 2013 (Particulate filter mandatory)

2006+ Emission Standards

	Rated Power	NOx	HC	CO	PM	Start
		(g/kWh)				
Diesel	19 kW – 37 kW	6.0	1.0	5.0	0.4	01/10/07
	37 kW – 56 kW	4.0	0.7	5.0	0.3	01/10/08
	56 kW – 75 kW				0.25	
	75 kW – 130 kW	3.6	0.4	5.0	0.2	01/10/07
	130 kW – 560 kW	3.6	0.4	3.5	0.17	01/10/06
Gasoline	19 kW – 560 kW	0.6	0.6	20	-	2007

Small Utility Gasoline Engines (≤ 19 kW)

Voluntary standards from LEMA.
LEMA Tier 1 standards are aligned on EU Stage I and US EPA Tier 1
LEMA Tier 2 standards are aligned on EU Stage II and US EPA Tier 2
Implementation dates: Tier 1: SN and SH: 2003
Tier 2: SN: 2008; SH: 2011

Durability: Diesel: P ≤ 37 kW: 5,000 h Gasoline: 5,000 h
P > 37 kW: 8,000 h

REQUIREMENTS IN OTHER AREAS OF THE WORLD

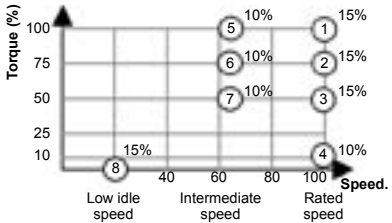
Canada	Alignment on US EPA Tier 2 and Tier 3
Croatia	Dir 77/537/EEC and Dir 97/68/EC - ECE R24
India	Agricultural and Forestry tractors: Bharat TREM III: HC + NOx: 9,5; CO: 5,5; PM: 0,8g/kWh Bharat Stage III A (TREM) equiv. EU Stage III A engines < 37 kW: from Apr 10; engines ≥ 37 kW: from Apr 11 Construction machinery: Bharat Stage II (CEV) equiv. to EU Stage I Bharat Stage III (CEV) equiv. US Tier 2/3 from Apr 11
Norway	Dir 77/537/EC and Dir 97/68/EC - ECE R 24 test procedure
PR of China	Stds equiv. to EU Stage I/II reg. Smallest engines are covered by US Tier 1/2stds - Stage I: Oct 07; Stage II: Oct 09
Russia	GOST R41 96-99 equiv. to EU Stage I Dir 77/537/EC and Dir 97/68/EC – ECE R24 test procedure
Singapore	Off-road diesel engines must comply from Aug 00: either Japan or US Tier I or EU Stage I standards Test Cycle ISO 8178-4 C1
South Korea	Engines for construction and industrial equipment: Korean Tier 3 equivalent to US Tier 3 - TA: 01 Jan 08
Switzerland	New engines for off-road veh. and machinery to meet current EU std Stationary Diesel and gas engines: max PM ≤ 50 mg / Nm^3 Diesel equipment used in underground: DPF mandatory Equipment < 50 kW operated < 2hrs/shift are exempt General construction (BUWAL): diesel engines operated within large construction sites must be fitted w/ DPF Large construction site: City: min 4 000m^2, 1 year Country: min 10 000 m^2, 1,5 year Smoke capacity limits for vehicles w/out DPF: - naturally aspired engines: 2,5 m^{-1} - turbocharged engines: 3,0 m^{-1} for vehicles w/ DPF: 0,24 m^{-1} Gasoline construction engines (idle): CO: 35 000 cm^3/m^3; HC: 500 cm^3/m^3 Diesel construction machines / equipment ≥ 18 kW: PN: 10^{12} /kWh EU NRMM requirements for eng. ≥ 37 kW: 01 Jan 09 18 to 37 kW: 01 Jan 10 Existing machines ≥ 37 kW built 2000-2008: compliance by 01 May 10 built bef. 2000: compliance by 01 May 15
Turkey	Harmonisation w/ EU regulation but w/ different application dates

TEST CYCLES

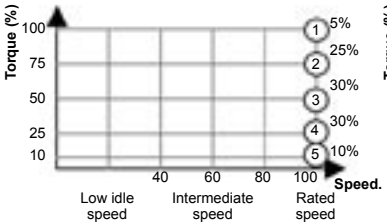
NRSC Test

With warm engine, raw exhaust emissions are measured during a prescribed sequence of operating conditions. The test cycle consists of a number of speed and load modes. Intermediate speed is the maximum torque speed if it occurs between 60% and 75% of rated speed or 60% of rated speed if this is higher or 75% if this is lower.

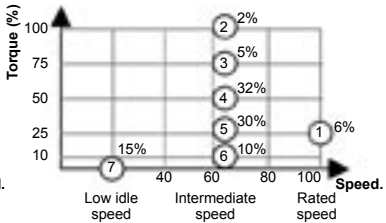
C.I. engines ISO 8178-C1 intermittent



C.I. engines ISO 8178-D2 constant speed

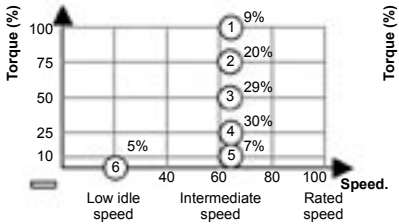


ISO 8178-C2 S.I. engines > 20kw

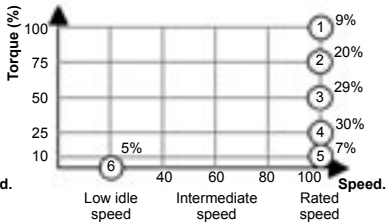


TEST CYCLES

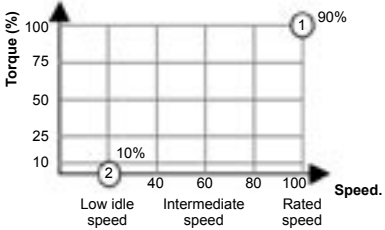
ISO 8178-G1
Non handheld intermediate speed applications



ISO 8178-G2
Non handheld rated speed applications



ISO 8178-G3
Handheld rated speed applications



For stage 1, 0,85 and 0,15 respectively

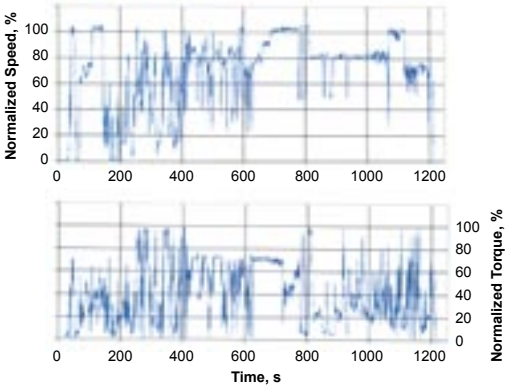
Intermediate speed is the maximum torque speed if it occurs between 60% and 75% of rated speed
or 60% of the rated speed if this is higher
or 75% of the rated speed if this is lower

TEST CYCLES

NRTC Test

The NRTC test has been developed by the US EPA in cooperation with the EU authorities. It will be used for both US EPA Tier 4 and EU Stage III regulations.

The NRTC is run twice (cold start/hot start) with the weighted PM being an
- average of the hot (90%) and cold (10%) cycles for EU Stage III
- average of the hot (95%) and cold (5%) cycles for US Tier 4



GLOSSARY

ABT	Average, Banking & Trading
ACEA	European Car Manufacturer Association
COP	Conformity of Production
DF	Deterioration Factor
ECE	Economic Commission for Europe, European subgroup of United Nations
EEV	Enhanced Environmentally Friendly Vehicle
EOBD	European Union On Board Diagnostic
EPA	US Environmental Protection Agency
ELR	European Load Response
ESC	European Stationary Cycle
ETC	European Transient Cycle
EU	European Union, formally called EEC or EC
Evap	Evaporative Emissions
FC	Fuel Consumption (EU)
FE	Fuel Economy (US)
FEL	Family Emissions Limits
FR	First Registration, entry into service
FTP	Federal Test Procedure
GTR	Global Technical Regulation (UN-ECE)
GVW	Gross Vehicle Weight
GVWR	Gross Vehicle Weight Rating
HDDTC	Heavy Duty Diesel Transient Cycle
HDGTC	Heady Duty Gasoline Transient Cycle
LBS	Pounds (1 lb = 454 g)
LDT	Light Duty Truck
LDV	Light Duty Vehicle = Passenger car ≤ 12 passengers
LEV	Low Emission Vehicle (LEV1, LEV2)
MTBE	Methyl Tertiary Butyl Ether
MVEG	Motor Vehicle Emissions Group, advisory expert committee To the European Commission
MY	Model Year
NHV	Net Heating Value of Fuel (US Fuel Economy Meas. Method)
NLEV	National Low Emission Vehicle
NMHC	Non Methane Hydrocarbons
NMOG	Non-Methane Organic Gases
OBD	On Board Diagnostic
OTL	OBD Threshold Limit
OMHCE	Organic Material Hydrocarbon Equivalent
PM	Particulate Matter
ppm	Parts per million
SHED	Sealed House for Evaporation Determination
SULEV	Super Ultra Low Emission Vehicle
TA	Type Approval
TLEV	Transitional Low Emission Vehicle
ULEV	Ultra Low Emission Vehicle (ULEV1, ULEV2)
VT SHED	Variable Temperature SHED
WHSC	Worldwide Heavy Duty Steady-State Cycle
WHTC	Worldwide Heavy Duty Transient Cycle
WWH-OBD	Worldwide Harmonized Heavy Duty OBD
ZEV	Zero Emission Vehicle

Ultra high pressure at the head of the class.

The new Delphi High Pressure Heavy Duty Diesel Common Rail System is among the most advanced fuel systems in the world. Its ultra high pressure (up to 3,000 bar) capability provides the potential to minimize the need for expensive aftertreatment.The system is designed for 4- to 16-liter diesel engine programs and is suitable for on- and off-road applications.

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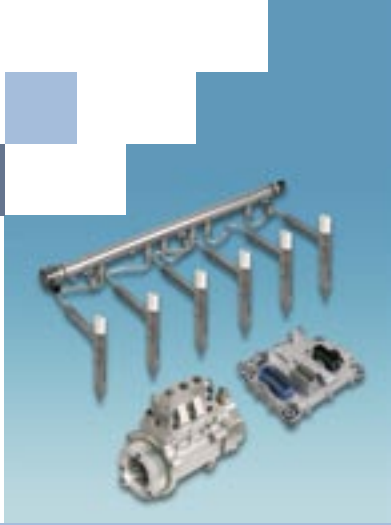

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