EMISSIONS RELATED REQUIREMENTS

EUROPEAN ON-BOARD DIAGNOSTICS

OBD permits rapid detection of failure of emission critical components and systems on vehicles. **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		
Row C (EEV)		

OBD Stage I (Euro IV) (Diesel engines only)
TA: from 01 Oct 05 FR: from 01 Oct 06

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 08 FR: from 01 Oct 09

Monitoring Area: Stage I monitoring area, except monitor for MFF (Major Functional Failure) 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 emission related component (air flow, EGR, etc) if a malfunction causes increase above threshold.
- Check of circuit continuity of any other emission related 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.

EUROPEAN ON-BOARD DIAGNOSTICS

Requirements for Correct Operation of NOx Control Measures

Application date: TA from 09 Nov 06 FR from 01 Oct 07

1) In case of engine systems requiring a reagent, NH3 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 (Malfunction Indicator Light)
   - NOx level > 1.5 g/kWh above the applicable NOx limit => MIL
   - NOx level exceed OBD (7.0 g/kWh) => torque limiter activation
   - Record of the fault for at least 400 days or 9,600 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 1,600 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

Euro VI OBD (Reg EC N° 595/2009 and (EU) N° 582/2011)

Implementation dates: NEW Types	Implementation dates: ALL Types	OBD Limits (mg/kWh)					
		P.I. Engines	C.I. Engines	All Engines			
		CO	PM	NOx	IUPR[2)]	Reagent quality & consumption monitoring	Additional OBD requirements
31 DEC 12 (phase-in)	31 DE C13		Performance monit.[1)]	1.500	Phase-in[3)]	Phase-in[3)]	N/A
01 SEP 14	01 SEP 15	7.500	–	1.500	Phase-in[3)]	Phase-in[3)]	N/A
31 DEC 15 (gen. req.)	31 DEC 16	7.500	25	1.200	General[4)]	General[4)]	Yes (5)

1) Performance monitoring requirements applies for particulate aftertreatment device.
2) IUPR – In-use performance ratio.
3) Phase-in requirements shall apply.
4) General requirements shall apply.

US 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.

Note: CARB OBD II compliance is required (i.e. not optional) for many states.

CALIFORNIA (CARB) ON-BOARD DIAGNOSTICS

CARB HD OBD

CCR Title 13, sec. 1971.1: MY 2013+ (OAL Approved by 13 Jul 2013) DIESEL VEHICLES

Monitor Area	Condition for Malfunction
Fuel System - Pressure Control - Injection Quantity - Injection Timing	a) NMHC, NOx, CO: 2,0 x standard b) PM: Standard + 0.02 grams/bhp-hr Note: Failure modes incl. both single & all injectors equally deteriorated
- Feedback Control	a) Fails to begin control within manufacturer-defined time b) Failure or deterioration causes open loop or default operation c) Control max. authority reached & cannot achieve control target
Misfire monitoring during idle (systems w/o combustion sensor) Continuous monitoring for all positive engine torque speed/loads (systems with combustion sensor)	Misfire detection level: - 2013-2015 MY: (Veh. w/comb. Sensor) 5% misfire detection - 2016 MY: 20%; 2017 MY: 50%; 2018+ MY: 100%. Applies low-level misfire detection to ALL vehicles (must detect 5% misfire) - Vehicles w/o comb. Sensor and not part of above phase-in: one or more cylinders continuous misfire Monitoring conditions: - (volumes not incl. in phase-in below): monitoring region restricted by 20-75% of peak torque and up to 75% max engine speed - 2019 MY: 20%; 2020 MY: 50%; 2021 MY: 100%. Monitoring required under ALL positive torque engine speed conditions, except: 1) Positive torque line to 50% max engine speed @ positive torque line 2) 100% max engine speed & (+10%) torque above positive torque line
Exhaust Gas Recirculation (EGR) - Low Flow Rate - High Flow Rate (incl. leaking EGR valve bypass flow) - Slow response (both increasing and decreasing directions) - EGR Cooler Performance (monitoring of multiple coolers requires Executive Officer approval)	a) NMHC, NOx, CO: 2,0 x standard b) PM: Standard + 0.02 grams/bhp-hr

Monitor Area	Condition for Malfunction
- Feedback Control	a) Fails to begin control within manufacturer-defined time. b) Failure or deterioration causes open loop or default operation. c) Control max. authority reached & cannot achieve control target. Note: a) and b) may be met by monitoring of EGR input parameters instead of system, if all equivalent failure modes are detectable
- EGR Catalyst Performance	No detectable amount of constituent oxidation (monitoring not required if no emission impact under driving condition where impact is most likely)
Boost Pressure Control System - Underboost - Overboost - Slow Response (Boost System) - Charge Air Undercooling (monitoring of multiple coolers requires Executive Officer approval)	a) NMHC, NOx, CO: 2,0 x standard b) PM: Standard + 0.02 grams/bhp-hr
- Feedback Control	a) Fails to begin control within manufacturer-defined time b) Failure or deterioration causes open loop or default operation c) Control max. authority reached and cannot achieve control target Note: a) and b) may be met by monitoring of Boost pressure input parameters instead of system, if all equivalent failure modes are detectable
NMHC Converting Catalyst (exl. downstream or PM filter for regen) - Conversion Efficiency - Other Aftertreatment Assistance Function	a) NMHC: 2,0 x standard b) NOx: standard + 0.2 g/bhp-hr Exotherm generation (PM Filter regen assistance): - Catalyst unable to generate sufficient exotherm for regen. Feedgas constituency (SCR assistance): - Catalyst unable to generate sufficient feedgas for proper SCR operation, with no monitoring required if < 15% emission increase and < std. under test cycle NMHC conversion downstream of PM filter for us during regen: - No detectable amount of NMHC conversion Converter downstream of SCR system - No detectable amount of NMHC,CO, NOx or PM conversion capability

CALIFORNIA (CARB) ON-BOARD DIAGNOSTICS

Monitor Area	Condition for Malfunction
NOx Converting Catalyst - Conversion Efficiency	- 2013-2015 MY (not part of below phase-in volume): standard +0.4 g/bhp-hr NOx, 2,0 x standard NMHC - Phase-In Requirement (2014 MY: 20%; 2015 MY: 50%): standard +0.3 g/bhp-hr NOx, 2,0 x standard NMHC - 2016 + MY: standard + 0,2 g/bhp-hr NOx, 2,0 x standard NMHC (Note: carry-over allowed from previous 2014 or 2015 phase-in volume certification for 2016 MY only)
- Selective Catalytic Reduction (SCR)	Reductant Other than engine's fuel: - Insufficient reductant for proper operation - Improper reductant in reservoir/tank - 2013-2015 MY (not part of below phase-in volume): standard +0.4 g/bhp-hr NOx, 2,0 x standard NMHC - Phase-In Requirement (2014 MY: 20%; 2015 MY: 50%): standard +0.3 g/bhp-hr NOx, 2,0 x standard NMHC - 2016 + MY: standard + 0,2 g/bhp-hr NOx, 2,0 x standard NMHC (Note: carry-over allowed from previous 2014 or 2015 phase-in volume certification for 2016 MY only)
- Feedback Control	a) Fails to begin control within manufacturer-defined time b) Failure or deterioration causes open loop or default operation c) Control max. authority reached and cannot achieve control target Notes a) and b) may be met by monitoring of NOx catalyst input parameters instead of system, if all equivalent failure modes are detectable
NOx Adsorber	
- Capability	- NOx: standard + 0.2 g/bhp-hr, 2,0 x standard NMHC
- Active/Intrusion Injection	- Unable to achieve desorption of the NOX adsorber
- Feedback Control	a) Fails to begin control within manufacturer-defined time b) Failure or deterioration causes open loop or default operation c) Control max. authority reached and cannot achieve control target Notes a) and b) may be met by monitoring of NOx adsorber input parameters instead of system, if all equivalent failure modes are detectable
Particulate Matter Filtering Filtering Performance	- 2013-2015 MY (not part of below phase-in volume): higher of 0.05 OR standard + 0.04 g/bhp-hr PM, & maintain relief for certain failure mode exemptions - 2014-2016 MY: 2 options for manufacturers to "phase-in":

Monitor Area	Condition for Malfunction
Option 1	- 2014-2015 MY: 20% higher of 0.05 OR std. + 0.04 g/bhp-hr PM, with NO failure mode relief. Remaining vol. same as 2013 MY - 2016 MY: 20% phase-in volume will carry-over, while remaining vol. must meet higher of 0.03 OR std. + 0.02 g/bhp-hr PM, with NO failure mode relief - 2017+ MY: 100% higher of 0.03 OR std. + 0.02 g/bhp-hr PM, with NO failure mode relief
Option 2	- 2014 MY: carry-over 2013 MY requirements - 2015 MY: 50% higher or 0.03 OR std. + 0.02 g/bhp-hr PM, with NO failure mode relief. Remaining vol. carry-over from 2014 MY - 2016+ MY: 100% higher of 0.03 OR std. + 0.02 g/bhp-hr PM, with NO failure mode relief
- Frequent Regeneration	a) NMHC: 2,0 x standard b) NOx: standard + 0.2 g/bhp-hr
- Incomplete Regeneration	Improper regeneration where regeneration is designed to occur under manufacturer-defined conditions
- NMHC Conversion	NMHC: 2,0 x standard, with no monitoring required if < 15% emission increase AND < standard under test cycle
- Missing Substrate	a) PM filter substrate completely destroyed, removed, or missing b) PM filter assembly replaced with a muffler or straight pipe
- Active/Intrusion Injection	(fuel injected to achieve regen. of the PM): unable to achieve regen.
- Feedback Control	a) Fails to begin control within manufacturer-defined time b) Failure or deterioration causes open loop or default operation c) Control max. authority reached and cannot achieve control target Notes a) and b) may be met by monitoring of PM changes input parameters instead of system, if all equivalent failure modes are detectable
Feedgas Constituency (SCR assistance)	- 2016+ MY: PM Filter unable to generate sufficient feedgas for proper SCR operation, with no monitoring required if < 15% emission increase AND < standard under test cycle.

CALIFORNIA (CARB) ON-BOARD DIAGNOSTICS

Monitor Area	Condition for Malfunction
Exhaust Gas Sensors - All Sensors	a) Lack of circuit continuity b) Out of "normal" range
- A/F Sensors - Upstream of Exhaust Treatment	- Sensor Performance: a) NMHC, CO, NOx: 2,0 x standard b) PM: standard + 0.02 g/bhp-hr - Feedback: failure or deterioration causes an emission control system to stop using that sensor as an input (default or open loop) - Monitoring capability: any characteristic no longer sufficient for use as input to other monitoring strategy
- A/F Sensors - Downstream of Exhaust Treatment	- Sensor Performance: a) NMHC: 2,0 x standard b) NOx: standard + 0.2 g/bhp-hr c) PM: 0.03 g/bhp-hr (FTP or SET), OR std. + 0.02 g/bhp-hr whichever is higher - Feedback: failure or deterioration causes an emission control system to stop using that sensor as an input (default or open loop) - Monitoring capability: any characteristic no longer sufficient for use as input to other monitoring strategy
- NOx & PM Sensor Performance	- 2013-2015 MY (not part of below phase-in volume): std. +0.4 g/bhp-hr NOx, higher of 0.03 g/bhp-hr OR std. +0.02 g/bhp-hr PM - Phase-In Requirement (2014 MY: 20%; 2015 MY: 50%): std. + 0.3 g/bhp-hr NOx, higher of 0.03 g/bhp-hr OR std. + 0.02 g/bhp-hr PM - 2016+ MY: 100%: std. + 0.2 g/bhp-hr NOx, 2,0 x std. NMHC, higher of 0.03 g/bhp-hr OR std. + 0.02 g/bhp-hr PM. Note that manufacturer is allowed to carry-over from previous 2014 or 2015 phase-in volume certification for the 2016 MY only. - Feedback: failure or deterioration causes an emission control system to stop using that sensor as an input (default or open loop) - Monitoring capability: any characteristic no longer sufficient for use as input to other monitoring strategy

Monitor Area	Condition for Malfunction
- Other Exhaust Sensors	Manufacturer to submit plan and obtain approval of Exec. Officer
- Exhaust Gas Sensor Heaters	a) Current or voltage drop no longer with sensor manufacturer's limits for normal operation b) Faults that result in conflict between commanded & actual state of the heater
Variable Valve Timing and/or Control - Target Error (outside crank angle and/or lift tolerance) - Slow Response	a) NMHC, CO, NOx: 2,0 x standard b) PM: standard + 0.02 g/bhp-hr
Cold Start Emission Reduction Strategy	a) Any single commanded element does not respond properly: - By a robustly measurable amount - In the commanded direction - By an amount that is greater than otherwise would have been commanded without the cold start strategy activated b) Deterioration: - NMHC, NOx, or CO: 2,0 x standard - PM: standard + 0.02 g/bhp-hr c) Cold Start System Capability: - Desired effect not achieved (as feasible) - Individual elements/components (when desired effect method is NOT feasible) Note: Fault codes must isolate cold start related failures

CALIFORNIA (CARB) ON-BOARD DIAGNOSTICS

CARB HD OBD – Gasoline Vehicles

Monitor Area	Condition for Malfunction
Fuel System	Fuel delivery system: 1,5 x std. (all constituents) Feedback control: 1,5 x std. (all constituents) A/F cylinder imbalance: 2014-2016 MY: 3,0 x std. (all constituents); 2017+ MY: 1,5 x std. (all constituents)
- Feedback Control	a) Control max. authority reached (if based on secondary oxygen sensor, allowed to also verify if control target is achieved prior to failure) b) Fails to begin control within manufactured-define time (time period requires Exec. Officer approval). Engine off strategies must monitor every engine start.
Misfire Continuous monitoring for all positive engine torque speed/loads from the 2nd crankshaft revolution after engine start (150 rpm below normal, warmed-up idle speed)	a) 1,5 x std. (all constituents) - single detection of misfire rate in 1st 1000 engine revolutions - 4 detections of misfire rate in 1000 engine revolution blocks b) Misifre rate that causes temperature to reach catalyst damaging level Specific cylinder DTC required for > 90% misfire occurring on a single cylinder
Exhaust Gas Recirculation (EGR) - Low Flow Rate - High Flow Rate (incl. leaking EGR valve bypass flow)	1,5 x std. (all constituents)
Cold Start Emission Reduction Strategy	a) Any single commanded element does not respond properly: - By a robustly measurable amount - In the commanded direction - By an amount that is greater than otherwise would have been commanded without the cold start strategy activated b) Deterioration and Cold Start System Capability (desired effect not achieved OR individual elements/components not achieved):
	- 1,5 x std. (all constituents) Note: fault codes must isolate cold start related failures
Secondary Air System	1,5 x standard (all constituents) - Both reduction in secondary flow and excessive secondary flow must be monitored - Monitoring required while control strategy is normally activated - When < 1,5 x standard due to failure, must monitor control system for being at the limit of authority to reduce air delivery
Catalyst	Conversion capability: a) NMHC, NOx: 1,75 x standard b) NMHC conversion efficiency below 50% For threshold testing purposes, the catalyst system is to be aged simultaneously (full catalyst volume) - If fuel is shut off for misfiring cylinder, the monitored volume catalyst(s) must be aged simultaneously to the threshold limit, while unmonitored volume must be aged to the end of the vehicle's full useful life
Evaporative System	a) No purge flow (must monitor all purge flow paths) b) Cumulative evaporative system leak ≥ 0.150" orifice (may be revised upward for techn. incapability or < 1,5 x std. with Exec Officer approval) Note: MIL illumination not required for approved alternate indicator for fuel cap missing or improperly secured. Alternate fuel engines require Executive Officer approval of a strategy equating to gasoline
Exhaust Gas Sensor - Primary & Secondary Exhaust Gas Sensors	a) Sensor Performance: - 1,5 x standard (all constituents) - (Primary sensors only): symmetric and asymmetric delay to respond and response rates, lean-to-rich and rich-to-lean (certification data/analysis required) b) Lack of circuit continuity c) Out of "normal" range

CALIFORNIA (CARB) ON-BOARD DIAGNOSTICS

Monitor Area	Condition for Malfunction
	d) Feedback: Failure or deterioration causes fuel system to stop using that sensor as an input (default or open loop) - (Primary sensors only): delayed entry to closed loop e) Monitoring Capability: Any charcteristic no longer sufficient for use as input to other monitoring strategy
- Exhaust Gas Sensor Heaters	a) Current or voltage drop no longer within sensor manufacturer's limit for normal operation b) Faults that result in conflict between commanded and actual state of the heater
Variable Valve Timing and/or Control - Target Error (outside crank angle and/or lift tolerance) - Slow Response	1,5 x std. (all constituents)

CARB HD OBD – ALL Vehicles

Monitor Area	Condition for Malfunction
Engine Cooling System - Thermostat	a) Engine coolant temperature does not reach the following within Executive Officer approved time. - Within 20 deg F of normal operating temp (may use higher threshold if < 50% emissions increase; may disable when ambient temp < 20 deg F) - Highest temp required by the OBD system to enable other monitors b) 2016 + MY: Engine coolant temperature reaches the temp defined above, but then drops below the highest temperature required by OBD system to enable other monitors Note: must disable thermostat monitoring for (thermostat threshold – StartUp coolant temperature < 35 deg F). Executive Officer approval required to enable in this temperature range.

Monitor Area	Condition for Malfunction
- Engine Coolant Temperature Sensor	a) Circuit continuity b) Time to reach closed-loop/feedback enable temp c) Stuck in range below the highest min enable temp required by other monitors d) Stuck in range above the lowest max enable temp required by other monitors (exemption allowed when temp gauge is based on same sensor and indicates overheating)
Crankcase Ventilation (CV) - Includes all CV-related external tubing/hoses	Disconnect of CV system (possible exemptions follow): a) Between Crankcase and CV Valve b) Between CV Valve and Intake Ducting Exemptions may apply (with Executive Officer approval) for: – Systems where vehicle operator is certain to respond or where disconnection of an unmonitored portion first requires disconnection of a monitored portion – Connection between Crankcase and CV Valve, when tubing is used such that it is resistance to deterioration or disconnection, difficult to remove relative to connection between CV Valve and Intake, and not part of non-CV repair/maintenance – Connection between CV Valve and Intake, when the disconnection either causes the vehicle to stall OR CV design is integral to the induction system (no tubing, hoses, etc.) Engines certified on an engine dynamometer and having open CV system (vent to atmosphere): monitoring plan to be provided for Exec Officer review/approval
Comprehensive Components	– Monitoring required for any input or output compon. that can impact emissions (by any amount) under any reasonable driving condition. – Those components/systems that affect only engine mechanical or electrical load (not related to fuel, air, or emissions control) are only to be monitored if they are used by any other system or compon. monitor.

CALIFORNIA (CARB) ON-BOARD DIAGNOSTICS

Monitor Area	Condition for Malfunction
	– Hybrid monitoring requires Exec Officer approval: at a min, must monitor components. used by any other system or component monitor, energy input devices, battery and charging system performance, electric motor performance, and regenerative braking performance.
- Vehicle Speed (when received by OBD system from another controller, such as transmission control unit)	a) Monitoring as Input Component, as feasible (refer to "Input Components" below) b) Unable to properly receive vehicle speed information (communication failure) c) If other controller monitors the vehicle speed info & provides "invalid" determination, must handle as default mode of operation (with MIL illumination) for the OBD systems
- Input Components	a) Lack of circuit continuity b) Out of "normal" range c) Irrational sensor value (2-sided monitoring) d) Alternate Strategy Activation (that can affect emissions): – Malfunctions that cause the system to erroneously activate or deactivate – Failures that invoke erroneous control, as feasible (rationality) e) Components used for emission control strategies not specifically addressed by CARB regulations. – Failures that cause the strategy to not operate in its intended manner (delayed enable, erroneous exit, authority limit) f) Camshaft/Crankshaft Position Sensors: – Engines requiring precise cam/crank alignment: improper alignment – Engines equipped with VVT and belt/chain: one or more tooth improper alignment (larger if no emission impact for single tooth)
- Output Components	a) Improper functional response, as feasible b) Circuit continuity faults c) Idle Control System (Gasoline engines w/monitoring strategies based on deviation from target idle speed): – Speed control cannot maintain within 200 rpm above or 100 rpm below the target idle speed – Speed control cannot maintain within the smallest engine speed tolerance range for any other monitor's enable d) Idle Control System (Diesel Engines): – Speed control cannot maintain within +/- 50% of target speed – Speed control cannot maintain within the smallest engine speed tolerance range for any other monitor's enable Idle control cannot achieve the target idle speed with fuel injection quantity within (smallest quantity tolerance range for enabling other monitors) OR (+/- 50% of properly functioning quantity) e) Glow Plugs/Intake Air Heaters: – Improper functional response – Circuit continuity faults – Proper current and voltage drop – Single glow plug no longer operates in manufacturer's limits f) "Wait to Start" Lamp: failures that prevent illumination g) Components used for emission control strategies not specifically addressed by CARB regulations: - Failures that cause the strategy to not operate in its intended manner (delayed enable, erroneous exit, authority limit) h) "Tolerance Compensation": Improper compensation being applied by controller for connected hardware, with no monitoring required if < 15% emission increase AND < std. under test cycle (Executive Officer review/approval required).

CALIFORNIA (CARB) ON-BOARD DIAGNOSTICS

Monitor Area	Condition for Malfunction
'Other' Emission Control Systems	Executive Officer approval required for proposed strategy. Engines utilizing emission control through intake air flow or cylinder charge characteristics: may monitor the shaft (incl. all segments) instead of air flow, cylinder charge, or individual valve(s)/flap(s).
Default (Limp-Home) Mode	MIL and fault code storage required, when emissions impact or OBD system performance is changed (includes controller failures)
General OBD Requirements – Full vs. Extrapolated OBD	2013-2015 MY (not including alternate fueled engines): Full OBD requirements to be met by: – ALL engine ratings within one selected family (highest weighted 2010 MY sales) – One engine rating for remaining families (highest weighted 2013 MY sales) Balance of volume to meet Extrapolated OBD (reduced monitoring requirements – Executive Officer approval required for all monitors) 2016+ MY All engine ratings & families to meet full OBD requirements Alternate Fueled Engines: 2013-2017 MY: EMD & NOx aftertreatment functional monitors 2018 + MY: Full OBD requirements apply Hybrid Vehicles: 2013 MY with base engine certification in 2013 (non-hybrid). Various relief possible, upon Executive Officer approval
In-Use Performance Ratio	Select monitors required to meet minimum ratio ≥ 0,100 2016 + MY: PM Filter/Heater Ratio calculation to be based on General Denominator
Exceptions to Monitoring Requirements	a) Executive Officer may revise emission thresholds or exempt certain PM failure modes (refer to PM monitoring). b) Disablement at (ambient temperature < 20 deg F or component freezing) OR (altitude > 8000 feet): Requires Executive Officer approval. c) Disablement at fuel level ≤ 15% full (OBD system must be capable of detecting faults at the disablement level and Executive Officer approval is required). d) Disablement at battery voltage < 11.0 V (Exec. Officer approval required for use of higher level of low voltage for disable, as well as disablement for high voltage with accompanying voltage monitor). e) Disablement for PTO activation (requires PTO activation time and IM Readiness reset at 750 minutes activation without related monitor completion). f) Exemption from component monitoring if no emissions impact for any reasonable driving condition AND component is not used for other OBD purposes. g) Small volume diesel manufacturers are allowed relaxed phase-in schedules for misfire, NOx catalyst, PM filter, and NOx sensor monitoring.

WWH ON-BOARD DIAGNOSTICS

ECE GTR5 (including Addendum 5)

- generic OBD requirements (Module A) (out of booklet scope)
- specific OBD emission related (Module B)
- in-use performance monitoring (Module C)

The OBD systems will have to

- detect malfunctions
- identify area of these malfunctions
- indicate their occurrence by means of a malfunction indicated (MI)
- 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 9)

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 – Engine Cooling system
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 Control System

Performance Requirement

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.

	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

FUEL CONSUMPTION – CO_2 EMISSIONS

EUROPEAN UNION

(See Page 16)

US FEDERAL

CO_2 and Fuel Consumption Standards

Both EPA's and NHTSA's joint final standards for the 3 main HD regulatory categories are summarized below:

Combination Tractors: The agencies have adopted differentiated standards for 9 sub-categories of combination tractors on 3 attributes: weight class, cab type and roof height. The standards will be in phase to the 2017 levels.

Proposed MY 2017 Combination Tractor Standards

	EPA Emissions Standards [g CO_2/ton-mile]			NHTSA Fuel Consumption Standards [gal/1,000 ton-mile]		
	Low Roof	Mid Roof	High Roof	Low Roof	Mid Roof	High Roof
Day Cab Class 7	104	115	120	10.2	11.3	11.8
Day Cab Class 8	80	86	89	7.8	8.4	8.7
Sleeper Cab Class 8	66	73	72	6.5	7.2	7.1

In addition to vehicle standards, engine-based standards must be met by heavy-heavy-duty (HHD) and medium-heavy-duty (MHD) diesel engines used in combination tractors, (MY fuel consumption standards are voluntary).

FUEL CONSUMPTION – CO_2 EMISSIONS

US FEDERAL

Engine standards for engines installed in tractors units

Engine	MY	CO_2 Emissions (g/bhp-hr)	Fuel Consumption (gallon/100 bhp-hr)
MHD	2014	502	4.93
	2017	487	4.78
HHD	2014	475	4.67
	2017	460	4.52

An optional compliance schedule is available, with more relaxed tractor engine standards to be met from 2013 and numerically identical final standards to be met from 2016.
CO2 emissions are tested on the same engine that is tested for pollutant emissions – typically the highest rated engine within an engine family. While this is the "worst case" rating for meeting pollutant emissions standards, it is typically the rating with the lowest specific CO_2 emissions within the engine family.

HD Pickup Trucks and Vans: The agencies are setting corporate average standards for HD pickup trucks and vans, similar to the approach taken for LD vehicles. Each manufacturer's standard for a MY depends on its sales mix, with higher capacity (payload and towing) having numerically less stringent target levels, and with an added adjustment for 4-wheel drive vehicles. This approach recognises both the inherently higher GHG emissions and fuel consumption of higher-capacity vehicles, and the importance of payload and towing capacity to the owners of these work trucks and vans.

EPA has established standards for this segment in the form of a set of target standard curves, based on a 'work factor' that combines a vehicle's payload, towing capabilities, and whether or not it has 4-wheel drive. The standards will phase in with increasing stringency in each MY from 2014 to 2018. The EPA standards adopted for 2018 include a separate standard to control air conditioning system leakage.

NHTSA is setting corporate average standards for fuel consumption that are equivalent to EPA's standards (though not incl. EPA's final air conditioning leakage standard). To satisfy leadtime requirements under EISA, NHTSA standards will be voluntary in 2014 and 2015. Both agencies are providing manufacturers with 2 alternative phase-in approaches that get equivalent overall reductions. One alternative phases the final standards in at 15-20-40-60-100% in MY 2014-15-16-17-18. The other phases the final standards in at 15-20-67-67-67-100% in MY 2014-25-16-17-18-19.

FUEL CONSUMPTION – CO_2 EMISSIONS

US FEDERAL

Estimated Total Vehicle CO_2 Reductions for HD Pickup Trucks & Vans for Alternative 2

GVWR Class	MY	CO_2 Reduction from 2010 MY Gasoline	CO_2 Reduction from 2010 MY Diesel
LHD 2b-3	2014	1.3%	2.0%
	2015	1.7%	2.7%
HHD	2016	3.4%	5.4%
	2017	5.0%	8.0%
	2018+	8.4%	13.4%

Vocational Vehicles: They consist of a very wide variety of truck and bus types including delivery, refuse, utility, dump, cement, transit bus, shuttle bus, school bus, emergency vehicles, motor homes, tow trucks, and many more. Vocation vehicles undergo a complex build process, with an incomplete chassis often built with an engine and transmission purchases from different manufacturers, which is then sold to a body manufacturer. In these rules, the agencies are regulating chassis manufacturers for this segment.The agencies have divided this segment into 3 regulatory subcategories: Light Heavy (Class 2b through 5), Medium Heavy (Class 6 and 7), Heavy Heavy (Class 8) which is consistent with the engine classification.

Vehicle Standards for Vocational Vehicle (MY 2017)

	CO_2 Emissions $(g/bhp-hr)	Fuel Consumption (gallon/100 bhp-hr)
LH Class 2b-5	373	36.7
MH Class 6-7	225	22.1
HH Class 8	222	21.8

The standards depicted here represent emission reductions from 6 to 9% from the 2010 baseline.

Engine Standards for Engines installed in Vocational Vehicles

Engine	MY	CO_2 Emissions (g/bhp-hr)	Fuel Consumption (gallon/100 bhp-hr)
LHD	2014	600	5.89
	2017	576	5.66
MHD	2014	600	5.89
	2017	576	5.66
HHD	2014	567	5.57
	2017	555	5.45
HH Gasoline	2016	627	7.06

FUEL CONSUMPTION – CO_2 EMISSIONS

US FEDERAL

Testing: the requirements for tractors and vocational vehicles include both engine and vehicle standards. Engine manufacturers are subject to the engine standards. Testing is conducted over one test cycle:

- Tractor engines are tested over the steady-state SET test
- Vocational engines are tested over the FTP transient test

Chassis manufacturers are subject to the vehicle standards. Vehicle standards compliance is typically determined based on a customized, sophisticated vehicle simulation model, called the Greenhouse gas Emission Model (GEM), developed by EPA specifically for this regulation. The regulation does not require chassis testing due to the large variety of vehicle configurations and the scarcity of HD chassis test facilities.

Instead of using a chassis dynamometer as an indirect way to evaluate real-world operation and performance, various characteristics of the vehicle are measured and these measurements are used as inputs to the model. These characteristics relate to key technologies applicable to a given truck category – incl. aerodynamic features, weight reductions, tire rolling resistance, presence of idle-reducing technology, vehicle speed limiters, …

Other Standards and Provisions

N_2O and CH_4 Standards: the regulation introduces emissions standards for nitrous oxide and methane.

- Engine testing (tractors and vocational):
  N_2O = 0.10 g/bhp-hr CH_4 = 0.10 g/bhp-hr
- Chassis testing (pickups and vans, FTP-75 & HFET) :
  N_2O = 0.05 g/mi CH_4 = 0.05 g/mi

Testing requirements start from MY 2015, consistently with the N_2O/CH_4 requirements for LD vehicles. The standards were designed to cap emissions at current levels to prevent N_2O/CH_4 emissions increases in future engines.

A/C Leakage: EPA has adopted standards to assure the low-leakage components are used in air conditioning systems designed for HD pickup trucks and vans, and semi trucks. The standard for larger A/C systems (capacity above 733 g) is measured in percent total refrigerant leakage per year, while the standard for smaller A/C systems (capacity of 733 g or less) is measured in grams of refrigerant leakage per year.

Useful Life: the EPA CO_2 emissions must be met over the engine's and vehicle's useful life. The useful life definitions for engines and for vehicles that use the respective engine categories are identical to those defined for criteria pollutant standards for MY 2004 and later HD engines:
LHDDE – 110,000 / MHDDE – 185,000 / HHDDE – 435,000 miles/10 yrs

FUEL CONSUMPTION – CO_2 EMISSIONS

CHINA

Implementation date from 01 Jul 14 for new certificated vehicles.
Implementation date from 01 Jul 15 for in production vehicles.
C-WTVC cycle is used for the fuel consumption (FC) test which is based on the WHVC with some of the acceleration and deceleration values reduced.

FC Limits for HD Diesel Semi-trailer Towing Vehicle, GB 30510-2014

Gross Combination Weight (GVW) [kg]	FC Limits [l/100 km]
GVW ≤ 18,000	33.0
18,000 < GVW ≤ 27,000	36.0
27,000 < GVW ≤ 35,000	38.0
35,000 < GVW ≤ 40,000	40.0
40,000 < GVW ≤ 43,000	42.0
43,000 < GVW ≤ 46,000	45.0
43,000 < GVW ≤ 49,000	47.0
49,000 < GVW	48.0

FC Limits for HD Diesel Vehicles, GB 30510-2014

Gross Vehicle Weight (GVW) [kg]	FC Limits [l/100 km]	
	for Truck	for Autodumper
3,500 < GVW ≤ 4,500	13.0	15.0
4,500 < GVW ≤ 5,500	14.0	16.0
5,500 < GVW ≤ 7,000	16.0	17.5
7,000 < GVW ≤ 8,500	19.0	20.5
8,500 < GVW ≤ 10,500	21.5	23.0
10,500 < GVW ≤ 12,500	25.0	25.5
12,500 < GVW ≤ 16,000	28.0	28.0
16,000 < GVW ≤ 20,000	31.5	34.0
20,000 < GVW ≤ 25,000	37.5	43.5
25,000 < GVW ≤ 31,000	43.0	47.0
31,000 < GVW	45.5	49.0

FC Limits for HD Diesel Vehicles, GB 30510-2014

Gross Vehicle Weight (GVW) [kg]	FC Limits [l/100 km]	
	for Bus	for City Bus
3,500 < GVW ≤ 4,500	12.5	14.0
4,500 < GVW ≤ 5,500	13.5	15.5
5,500 < GVW ≤ 7,000	15.0	17.5
7,000 < GVW ≤ 8,500	16.5	19.5
8,500 < GVW ≤ 10,500	18.5	22.5
10,500 < GVW ≤ 12,500	20.0	26.0
12,500 < GVW ≤ 14,500	21.5	30.5
14,500 < GVW ≤ 16,500	22.5	34.0
16,500 < GVW ≤ 18,000	24.0	37.5
18,000 < GVW ≤ 22,000	25.0	41.0
22,000 < GVW ≤ 25,000	27.5	45.5
25,000 < GVW	29.5	49.0