Informal document No. **GRPE-50-17**
(50th GRPE, 30 May-3 June 2005,
agenda item 1.3.)

WWH-OBD

GLOBAL TECHNICAL REGULATION (GTR)
DRAFT PROPOSAL – Version #9 – module C
050531

Editorial: Understanding the colours code in this document

Black denotes proposals from the Lyon and Geneva meetings (May 2005)

Brown and green denotes proposals that have not been reviewed in the Lyon and Geneva meeting (Note: in some cases there may be 2 proposals that have not yet been merged by the group in a single one)

Structure of the GTR:

Module A – Rationale
  Written/amended by the sponsor countries

Module B – GENERIC provisions
  - Scope of the GTR
  - General OBD requirements
  - Generic Annexes

Module C - Emission related module
  - Scope of the module: Heavy Duty Diesel engines
  - Emission related OBD provisions
  - Annexe to the emission related provisions

Module D – [Function 'YYY' related module]

Module E – [Function 'ZZZ' related module]

MODULE A STATEMENT OF TECHNICAL RATIONALE AND JUSTIFICATION

Module A: will be included by the sponsoring country in a later stage.

MODULE B GENERIC OBD PROVISIONS

Provisions for module B are specified in document informal document GRPE-50-16 (050602 GTR-B.doc)

MODULE C EMISSION – RELATED HEAVY-DUTY DIESEL OBD

1. SCOPE AND PURPOSE

1.1. Scope

This module sets out the requirements for On Board Diagnostic systems to detect, record and communicate emission related malfunctions from an on-road heavy-duty diesel fuelled engine system that would affect the environmental performance of that system. The package of information exchanged with the vehicle and the powertrain will be part of the monitored elements.

1.2. General appraisal of OBD benefits

This module specifies the elements concerning the OBD system to facilitate the diagnosis and maintenance of the emission related engine system and the possible enforcement of road-worthiness measures.
A quick and effective repair of emission related failures will result in environmental benefits.

2. APPLICATION

2.1. Application

This module applies to Heavy Duty Diesel fuelled compression ignition engine systems and Heavy Duty vehicles powered by Diesel fuelled compression ignition engine systems that are certified to regulated emission standards requiring the measurement of their exhaust emissions on an engine test-bed.

The provisions of this module are limited to the responsibilities of the engine manufacturer.
The approval of the installation of a certified emission-OBD system is not part of this module. The process of ensuring the proper installation (i.e. in accordance with the instructions of the present module) of the approved engine system by the vehicle manufacturer will be addressed separately by the regional authorities

2.2. Engine entities subject to certification

2.2.1. certification of an individual OBD system
The manufacturer of an engine system may apply for the certification of its OBD system by demonstrating that OBD system complies with all the provisions of the present GTR.

2.2.2. certification of an Emission-OBD family
The manufacturer of an Emission-OBD family may apply for the certification of its OBD system by demonstrating that the parent Emission-OBD system of this family complies with all the provisions of the present GTR.

2.2.3. certification of OBD system as member of a certified Emission-OBD family
The manufacturer of an engine system may apply for the certification of its OBD system by demonstrating that OBD system meets the criteria for belonging to an Emission-OBD family that has already been certified.

3. Definitions

The generic definitions in section 3 of module B of this gtr shall apply for the purpose of this module, unless qualified below.

3.1. Certification

Certification means the approval by an authority of the manufacturer's demonstration of compliance with the applicable provisions of this gtr.

3.2. Continuous monitoring OK

"Continuous monitoring", if used in the context of this module means sampling at a rate not less than one sample per second.
If a computer input or output component is sampled less frequently than one sample per second for engine control purpose, the signal of the component may instead be evaluated each time sampling occurs.

3.3. Deficiency

'*deficiency*' means, in respect of engine OBD systems, that up to two separate components or systems that are monitored contain temporary or permanent operating characteristics that impair the otherwise efficient OBD monitoring of those components or systems or do not meet all the other detailed requirements for OBD.
Engines or vehicles in respect of their engine may be type-approved, registered and sold with such deficiencies according to the requirements of section 4.3 of this Annex;

3.4. Diagnostic trouble code (DTC)

3.4.1. Pending DTC

"Pending DTC" is a DTC that is stored by the OBD system because a monitor has detected during current or last completed operating sequence a situation where a malfunction may be present.

3.4.2. Potential DTC

"Potential DTC" is a DTC that is stored by the OBD system because a monitor has detected a situation where a malfunction may be present but requires further evaluation to be confirmed.

3.4.3. Confirmed DTC

"Confirmed DTC" is a DTC that is stored when the OBD system has completed the evaluation of a monitor and determined that a malfunction exists.

3.4.4. Previously active DTC

"Previously active DTC" is a previously confirmed DTC that remains stored after the OBD system has completed the evaluation of a monitor and determined that a malfunction no longer exists.

3.5. Emission-OBD family

'Emission *OBD family*' means a manufacturer's grouping of engine systems having common methods of monitoring / diagnosing emission related malfunctions;

3.6. Emission-OBD system [or] OBD system

3.7. Engine System

"Engine system" means the engine as configured on a test-bench during the "engine" certification process and includes:
a) the engine's electronic management controller(s)
b) the exhaust after-treatment system(s)
c) any emission related component in the exhaust system which supplies

input to, or receives output from, the engine's electronic management controller(s); and
d)the communication interface (hardware and messages) between the engine's electronic management controller(s) and any other powertrain or vehicle control unit if the exchanged information has an influence on the control of emissions.

3.8. Emission related Malfunction

3.9. emission related electrical malfunctions

- An electrical [or functionality/rationality] failure of the engine system leading to an excess of at least x% of the engine certification emission limit of any of the regulated pollutants (x% as defined in this GTR)
- Note: definition are set in the generic part. Criteria for a failure to become a malfunction to be written here

3.10. Operating sequence

"An operating sequence" means the sequence used for determining the conditions for activating and/or extinguishing the MI. It consists of an engine start-up, an operating period, an engine shut-off, and the time until the next start-up, where the OBD monitoring is running and a malfunction would be detected if present;

3.11. [emission related] OBD test-cycle

"OBD test-cycle" means the cycle over which an engine system is operated on an engine test-bed to evaluate the response of an OBD system to the presence of a qualified deteriorated component.

3.12. Malfunction indicator (definitions associated with)

3.12.1. Continuous-MI

"Continuous-MI" means the malfunction indicator showing a steady indication at all times while the key is in the on (run) position with the engine running [ignition ON – engine ON].

3.12.2. 60s-MI

"60s-MI" means the malfunction indicator showing a steady indication from the time the key is moved to on (run) position with the engine running [ignition ON – engine ON] and extinguishing after 60 seconds or the key is moved to off, whichever occurs first.

3.12.3. On-demand-MI

"On-demand-MI" means the malfunction indicator showing a steady indication in response to a manual demand from the driving position when the key is in the on (run) position with the engine off.

3.12.4. MI status

"MI status" means the command status of the MI, being either continuous-MI, 60s-MI, on-demand-MI, or OFF.

3.13. Parent engine system [of an Emission-OBD family]

"Parent engine system" means an engine system selected from an Emission-OBD family in such a way that its OBD elements of design are representative from that OBD family.

3.14. Total Functional Failure

"Total Functional Failure" (TFF) means a malfunction leading to a complete loss of the desired function of a system. (e.g. a total functional failure of a catalyst designed for reduction of NOx emissions means no measurable conversion efficiency of the catalyst).

3.15. Definition to be adopted from other GTRs

Examples of such necessary definitions are those used in the provisions concerning monitoring (e.g. After treatment system - DPF - DeNOx - DeNOx/SCR type - NOx trap - Combined DeNox / DPF, etc…)

4. GENERAL REQUIREMENTS

4.1. Monitoring requirements

All emission related components and systems included in an engine system shall be monitored by the OBD system in accordance with the requirements of this module.
The OBD system shall also monitor its own components.

An authority may allow that a component or system need not be monitored by the OBD system if the manufacturer demonstrates that on-board technology is not available to monitor such components or systems.- to be worked in more detail – OK for the time being

If the manufacturer can demonstrate that, upon total failure or removal of a component or system, emissions would not exceed the OBD threshold limits, a functional monitor of this component or system shall be accepted.

Circuit failures, and to the extent feasible, functionality, and rationality failures of the engine system shall be monitored, unless all of the following conditions are met
- the failure results in an emission increase of any pollutant of less than 30% of the regulated emission limit, and
- the failure does not cause any emission to exceed the regulated emission limit, and
- the failure does not affect a component or system that is used for OBD monitoring.

4.1.1. Monitoring frequency

Monitors shall run either continuously or at any time where the monitoring conditions are fulfilled.
When a monitor does not run continuously, the manufacturer shall make it clear to the authority and describe the conditions under which the monitor runs.
The monitors shall run during the applicable OBD test-cycle specified in section 7.2.2. for that monitor.

For components or systems monitored continuously, it is not required to activate an output component/system for the sole purpose of monitoring that output component/system.

4.1.2. Categories of monitoring

There are five categories of monitoring:

Category 1: Emission Threshold monitoring, which consists of:

a) Direct emissions measurement via a tailpipe emissions sensor(s); and/or

b) Indication of an emissions increase via correlation of computer input/output information to actual emissions.
This correlation would typically be done on a test engine in a laboratory setting.

Category 2: Functionality monitoring, which consists of monitoring for functionality failures.

Category 3: Rationality monitoring, which consists of monitoring for rationality failures.

Category 4: Electrical circuit continuity monitoring, which consists of monitoring for circuit failures.

Category 5: Performance threshold monitoring, which consists monitoring parameters that are not correlated to emission thresholds. Such monitoring is typically done on input components to verify that they are operating within the proper range given engine conditions and/or the proper range to enable other OBD monitors. Monitoring for Total functional failures shall be considered as category 5 monitoring.

Depending on the type of technology and/or the type of malfunction, categories 2 to 5 monitoring can be preferred to categories 1a and 1b. In that case, the monitoring technique shall be shown by the manufacturer (through either technical considerations, test results, previous agreements, etc…), to be robust, timely and efficient.
Examples:

- An electrical failure may not request a correlation because this is a yes/no failure.
- A PM trap failure monitored via delta pressure may not request a correlation because it anticipates a failure.
- Category 2/3/4 monitoring of the fuel system may substitute a threshold monitor since it may cover the relevant failure modes before emission thresholds are exceeded.

When a tailpipe emission sensor is used for monitoring the emissions of a specific pollutant (Category 1a) all other monitors may be exempted from further correlation to the actual emissions of that pollutant. Nevertheless, such exemption shall not preclude the need to include these monitors as part of the OBD system as they are still needed for the purpose of fault isolation.

Note: A malfunction shall always be classified according to section 4.2 based on its impact on emissions, whatever the category of monitoring by which it is detected.

4.1.3. System specific monitors

Annex XX identifies the major existing systems on Heavy Duty Diesel engines based on the state of art at the time of publication of this GTR. Each system identified shall be subject to monitoring to detect emission related malfunctions. This does not preclude other systems from being monitored.

The appendices list the sub-systems or components expected to be monitored by the OBD system for each of these major systems and include the generally expected monitoring category applicable to each of these components.

As an alternative, and upon the agreement of the authority, other monitors may be used if the manufacturer demonstrates that these monitors result in detection of the considered malfunctions in compliance with the requirements of this GTR.

4.1.4. Status of a malfunction (pending, confirmed, previously active)

The monitoring system shall confirm the presence of a malfunction by the end of the operating sequence following its first detection. A "confirmed" failure shall lead to an activation of the alert system according to section 4.3

In the mean time, when a malfunction has been detected but is not yet confirmed, the possible failure is recorded with the "pending" status. A "pending" failure shall not lead to an activation of the alert system according to section 4.3.

In some specific cases (typically monitors using statistical models or considering fluids consumption), monitors need more than two operating sequences for detecting and confirming a malfunction. This may be allowed by the authority provided the manufacturer justifies (e.g. per technical rationale, experimental results, or in house experience, etc…) more operating sequences for having a robust monitoring.

When a confirmed failure is not any more detected by the system, and until this failure is erased from the computer memory according to section 4.4.1.2, the failure shall be given the "previously active" status and shall not lead to an activation of the alert system according to section 4.3.

4.2. Requirements for malfunction classification

The failure classification specifies into which class a failures has to be assigned when this failure is detected, according to section 4.1 of this module.

Remarks:
- It is recognised that there may be imprecision in the allocation of a fault to a particular class of failure.
- It is not required that the emissions are above the applicable threshold when this class of failure is reported

4.2.1. Class A malfunction

Class A malfunction means a failure or deterioration of the emission control system or its components where the OBD threshold limits (OTL) are assumed to be exceeded.

Note: It is not required that the emissions are above the OTL when this class of failure is reported to the operator or the OBD scan tool.

4.2.2. Class B1 malfunction

Class B1 malfunction means a failure or deterioration of the emission control system or its components which has the potential to lead to emissions above the OTLs but for which the exact influence on emission cannot be estimated and thus the actual emissions according to circumstances may be above or below the OTL
Malfunctions that restrict the ability of the OBD system to carry out monitoring shall be classified into class B1.

For example:
Failures detected by monitors,
- that infer emission levels based on readings of sensors that are not informing directly about the emission level, or
- that have restricted monitoring capability

will probably be class B1

4.2.3. Class B2 malfunction

Class B2 malfunction means a failure or deterioration of the emission control system or its components which, according to circumstances, are assumed to influence the emissions but not to a level that exceeds the OTL

4.2.4. Class C malfunction

Class C malfunction means a failure or deterioration of the emission control system or its components which, if monitored, is thereby assumed to influence the emissions but to a level that would not exceed the regulated emission limits.
Malfunctions that restrict the ability of the OBD system to carry out monitoring shall not be classified into class C.

4.3. Alert system

4.3.1. MI specification
The malfunction indicator shall be visible, even by daylight; its The malfunction indicator shall comprise a yellow warning signal identified by the F22 symbol in accordance with ISO Standard xxxx:yyyyy.

Failure or deterioration of components of the engine system that do not lead directly to an increase in emissions as indicated under paragraph 4.2 of this module (e.g. plugged particulate filter), may be indicated by a separate warning signal. This signal may employ a specific symbol, e.g. F01 in accordance with ISO Standard xxxx:yyyyy.

4.3.2. MI activation at "key-on"

The MI shall show a steady indication for a minimum of 3 seconds in the key on, engine off position and deactivate no later than 10 seconds after engine cranking to indicate that the MI is functional.
The MI-status shall indicate OFF during this functional check unless otherwise commanded to continuous-MI, 60s-MI, or on-demand-MI.

If the manufacturer elects to additionally indicate readiness status through the MI in the key on, engine off position and if the readiness status for one or more of the monitored components or systems is "not complete", the MI shall blink once per second for 5-10 seconds.
The MI-status shall indicate OFF during this indication of readiness status unless otherwise commanded to continuous-MI, 60s-MI, or on-demand-MI.

4.3.3. MI illumination schemes

4.3.3.1. Discriminatory Display

For the purpose of activating the MI, continuous-MI shall take precedent to 60s-MI and on-demand-MI.
For the purpose of activating the MI, 60s-MI shall take precedent to on-demand-MI.

4.3.3.1.1 Malfunctions of class A
The OBD system shall command a continuous MI upon storage of a confirmed DTC associated with a class A malfunction.

4.3.3.1.2 Malfunctions of class B

The OBD system shall command a '60s MI' upon storage of a confirmed DTC associated with a class B malfunction.

In addition, when a B1 counter reaches 200 hours, the OBD system shall command a continuous MI unless and until the conditions of section 4.3.3.3 are met.

4.3.3.1.3 Malfunctions of class C

The manufacturer may make available information on class C malfunctions through the use of an on-demand-MI which shall be available until the engine is started.

4.3.3.2. Non-discriminatory Display

The OBD system shall command a continuous MI upon storage of a confirmed DTC associated with a class A, B, or C malfunction.

4.3.3.3. MI De-Activation scheme

The 'continuous MI' is switched to a '60s MI' if a single monitoring event occurs and the failure that originally commanded the continuous MI is not again detected and a continuous MI is not commanded due to another malfunction.

The '60s MI' is deactivated if, during 3 subsequent sequential operating sequences, the failure is not again detected and the MI is not activated due to another class A or B malfunction.

4.3.4. Counters associated with malfunctions

4.3.4.1. MI Counters

4.3.4.1.1 Continuous MI Counter

The OBD system shall contain a Continuous MI Counter to record the hours run by the engine while a continuous MI is commanded, since the last occurrence of conditions that allowed the counter to be reset to zero.

The Continuous MI counter shall remain frozen (whether at zero or at a value greater than zero) if no Continuous MI is commanded. If starting from zero, the continuous MI counter shall begin counting as soon as a continuous-MI is commanded. If starting from a frozen value greater than zero, The Continuous MI counter shall begin counting from the point it had been frozen if a malfunction that results in a continuous MI is detected within 3 operating sequences from the point at which the continuous-MI counter had been frozen.

The continuous MI counter shall be reset to zero when:

ANNEX 1 after 3 operating sequences (or "more than 3 operating sequences have passed") since the counter was last frozen, and there is detection of a malfunction that results in a continuous MI;

ANNEX 2 40 warm-up cycles have completed without detecting a malfunction that results in a continuous MI; or

ANNEX 3 the scan tool commands a clear diagnostic information (ISO name??. This presumably only occurs after a repair.

Examples illustrating the logic are given in annex ?

Note: A 2 byte counter with 1 hour resolution is requested for the cumulative continuous-MI counter. WWH-OBD to consider the need for a similar requirement in this section

4.3.4.1.2 Cumulative Continuous MI Counter

The OBD system shall contain a Cumulative Continuous MI Counter to record the cumulative hours run by the engine over its life while a Continuous MI is commanded. This counter shall go up to the maximum count provided in a 2 byte counter with 1hour resolution.

The Cumulative Continuous MI counter shall remain frozen (whether at zero or a value greater than zero) if no Continuous MIL is commanded. The Cumulative Continuous MI counter shall begin counting from the point it had been frozen if a malfunction that results in a continuous MI is subsequently detected.

The Cumulative Continuous MI Counter shall not be reset to zero under any circumstances including a disconnection of the battery.

Examples illustrating the logic are given in annex ?

4.3.4.2. Counters associated with malfunctions of category B1

The OBD system shall contain at least one B1 Counter to record the hours run by the engine while a B1 category malfunction is present. Manufacturers may use additional B1 counters if desired.

The B1 Counter shall remain frozen if no B1 category malfunction is present. The B1 Counter shall begin counting from the point it had been frozen if a subsequent B1 malfunction is present within 3 operating sequences.

Note: WWH-OBD to consider improving the text in the following way:
The B1 Counter shall remain frozen (whether at zero or a value greater than zero) if no B1 category malfunction is present. If starting from zero, the B1 Counter shall begin counting as soon as a class B1 malfunction is detected. If starting from a frozen value greater than zero, The B1 Counter shall begin counting from the point it had been frozen if a subsequent B1 malfunction is detected present within 3 operating sequences from the point at which the B1 Counter had been frozen.

In the case where the B1 Counter has exceeded 200 hours, the OBD system shall set the counter to 190 hours when the OBD system has determined that a B1 Malfunction is no longer present. The B1 Counter shall begin counting from 190 hours if a subsequent B1 malfunction is present within 3 operating sequences.

Note: WWH-OBD to consider improving the text in the following way:
In the case where the B1 Counter has exceeded 200 hours and the OBD system subsequently determines that a B1 Malfunction is no longer present, the OBD system shall set the counter to 190 hours when the OBD system has determined that a B1 Malfunction is no longer present. The B1 Counter shall begin counting from 190 hours if a subsequent B1 malfunction is detected present within 3 operating sequences from the point at which the B1 Counter had been set to 190 hours.

The B1 Counter shall be reset to zero when:

ANNEX 1 Three Operating Sequences have occurred during which no B1 malfunctions have been detected; or

ANNEX 2 the scan tool commands a clear diagnostic information (ISO document xxx.yyy). This presumably only occurs after a repair.

Examples illustrating the MI de-activation process are given in annex ?

4.4. Diagnosis information

4.4.1. Recorded information

The information recorded by the OBD system shall be available upon off-board request in the following packages.

Use Case 1: information about the engine state
The purpose of this information package is to give access to the minimum data set considered as necessary to obtain the vehicle or engine state as regards its emission performance according to the present GTR.
A typical use of this information package may be wired or wireless Roadside checks performed by enforcement authorities

Use Case 2: Information about emission related malfunctions
The purpose of this information package is to give access to the expanded data set considered as necessary to determine readiness and characterise the malfunctions detected by the OBD system.
A typical use of this information package may be wired or wireless Periodic inspection by enforcement authorities.

Use Case 3: Information for diagnosis and repair ("Master data set")
The purpose of this information package is to give access to the full data set requested by this module.
A typical use of this information package may be Diagnostic servicing of the vehicle / engine.

4.4.1.1. information about the engine state

The purpose of this use case is to provide an enforcement agency with the Malfunction Indicator status and associated data (e.g. MI counter, readiness status).

The OBD system shall provide all information (according to the ISO xxxxx Part 2) for the external roadside check test equipment to assimilate the data and provide to the enforcement agent with the following information:

- The GTR (and revision) number
- Discriminatory/ non-discriminatory display
- The VIN (Vehicle Identification Number)
- Presence of a continuous MI.
- The Readiness status of the OBD system
- The number of engine operating hours since a continuous MI was last activated (MI counter)

The type of information access is read only.

4.4.1.2. Information about active emission related malfunctions

The purpose of this use case is to provide any inspection station with a subset of engine related OBD data including the Malfunction Indicator status and associated data (MI counter), a list of active/confirmed malfunctions of classes A and B and associated data (e.g. B1 time counter).
The OBD system shall provide all information (according to the ISO xxxxx Part 2) for the external inspection test equipment to assimilate the data and provide to the inspector with the following information:

- The GTR (and revision) number
- The VIN (Vehicle Identification Number)
- The Malfunction Indicator status

- The Readiness status of the OBD system
- The number of engine operating hours since a continuous MI was last activated (MI counter)
- The cumulated operating hours with a continuous MI.
- The confirmed DTCs for malfunctions of class A
- The confirmed DTCs for malfunctions of classes B (B1 plus B2)
- The confirmed DTCs malfunctions of class B1 and the number of engine operating hours from the B1 counters

The type of information access is read only.

4.4.1.3. Information for repair

The purpose of this use case is to provide repair technicians with a all OBD data specified in this module (e.g. Freeze Frame information)
The OBD system shall provide all information (according to the ISO xxxxx Part 2) for the external repair test equipment to assimilate the data and provide to the repair technician with the following information:

- The GTR (and revision) number
- The VIN (Vehicle Identification Number)
- The Malfunction Indicator status
- The Readiness status of the OBD system
- The number of engine operating hours since the Malfunction Indicator has been activated (MI counter)
- The active and confirmed malfunctions of class A
- The active and confirmed malfunctions of classes B (B1 and B2)
- The active and confirmed malfunctions of class B1 and the number of engine operating hours from the B1 counters
- The active and confirmed DTCs for malfunctions of class C
- The pending DTCs and their associated class
- The previously active DTCs and their associated class
- Realtime information on OEM selected and supported sensor signals, internal parameters and output signals
- The freeze frame data requested by this module (note from Bonn = if requested)
- The calibration identification number(s)
- The calibration verification number(s)
- Clear engine OBD system information

The OBD system shall clear all the recorded malfunctions of the engine system and related data (operating time information, freeze frame, etc..) upon request of repair technician when this request is provided via the external repair test equipment according to the ISO xxxxx Part 2.

4.4.1.4. Freeze frame information

note from Bonn = if requested)

4.4.2. Access to OBD information

In case of emission related OBD of Diesel Heavy-Duty engines, access to OBD information shall always be possible by means of a wired communication system.

4.5. Durability of the OBD system

The OBD system shall be designed to operate, for the actual life of the engine in which it is installed. In achieving this objective, the approval authority accepts that engines which have been used in excess of their

regulatory useful life may show some deterioration in OBD system performance such that the OBD thresholds may be exceeded before the OBD system signals a failure to the driver of the vehicle.

This section is not intended to extend the engine manufacturer's compliance liability for an engine beyond its regulated useful life (i.e., the time period during which emissions standards or emissions limits apply), except where an engine has been programmed or otherwise designed so that an OBD system deactivates based on age and/or mileage of the engine as prohibited under section 4.5 of the generic part of this GTR.

4.6. Electronic security

Any vehicle with an Emission Control Unit must include features to deter modification, except as authorised by the manufacturer. The manufacturer shall authorise modifications if these modifications are necessary for the diagnosis, servicing, inspection, retrofitting or repair of the vehicle.

Any reprogrammable computer codes or operating parameters must be resistant to tampering and afford a level of protection at least as good as the provisions in ISO 15031-7 (SAE J2186) provided that the security exchange is conducted using the protocols and diagnostic connector as prescribed in section 6 of Annex XIII. Any removable calibration memory chips must be potted, encased in a sealed container or protected by electronic algorithms and must not be changeable without the use of specialised tools and procedures.

Computer-coded engine operating parameters must not be changeable without the use of specialised tools and procedures (e.g. soldered or potted computer components or sealed (or soldered) computer enclosures).

Manufacturers must take adequate steps to protect the maximum fuel delivery setting from tampering while a vehicle is in-service.

Manufacturers may apply to the approval authority for an exemption from one of these requirements for those vehicles that are unlikely to require protection. The criteria that the authority will evaluate in considering an exemption will include, but are not limited to, the current availability of performance chips, the high-performance capability of the vehicle and the projected sales volume of the vehicle.
Manufacturers using programmable computer code systems (e.g. electrical erasable programmable read-only memory, EEPROM) must deter unauthorised reprogramming. Manufacturers must include enhanced tamper-protection strategies and write protect features requiring electronic access to an off-site computer maintained by the manufacturer. Alternative methods giving an equivalent level of tamper protection may be approved by the authority.'

5. Performance requirements

5.1. THRESHOLDS

In case the regional test-cycles (for emissions and OBD) are still applicable there are not any harmonisation of the OTLs

- In that case the OTLs would be selected within one of the following 3 sets of elements:

Note: [table tbd]

In case the test-cycles are harmonised, then the process for defining the OTLS on the basis of regional emission limits is world harmonised.

- In that case the OTLs would be selected within one of the following 3

sets of elements:

Note: [table tbd]

The following WW OTLs {empty table} are only applicable in the ultimate case the emissions limits are also World Harmonised

Note: [table tbd]

5.2. temporary disablement of the OBD system

An OBD system may be temporarily disabled under the conditions specified in the following sub-sections.
In all cases, the monitoring shall resume once the conditions justifying the disablement are no longer present.

5.2.1. safety

Monitoring may be disabled if continuation of monitoring might compromise the safety of the driver and/or anyone in proximity to the engine/vehicle. Monitoring shall resume once safety is no longer compromised.

5.2.2. ambient temperature and altitude conditions

OBD system monitors may be disabled at ambient engine start temperatures below [-7 degrees Celcius (20 degrees Fahrenheit)] (low ambient temperature conditions may be determined based on intake air or engine coolant temperature at engine start) or at elevations above [2500 meters (8202 feet)] above sea level if that the manufacturer has provided data and/or an engineering evaluation that demonstrate that monitoring during the conditions would be unreliable.
A manufacturer may further request an OBD system monitor be disabled at other ambient engine start temperatures upon determining that the manufacturer has demonstrated with data and/or an engineering evaluation that misdiagnosis would occur at the ambient temperatures because of its effect on the component itself (e.g., component freezing).

5.2.3. low fuel level

Monitoring systems that can be affected by low fuel level or runnings out of fuel (e.g., misfire detection) are allowed to disable for low fuel. Low fuel level is defined to be when the fuel level is 15 percent or less of the nominal capacity of the fuel tank.

5.2.4. vehicle battery or system voltage levels.

Manufacturers may disable monitoring systems that can be affected by vehicle battery or system voltage levels.

5.2.4.1. Low voltage

For monitoring systems affected by low vehicle battery or system voltages, manufacturers may disable monitoring systems when the battery or system voltage is below 90% of the nominal voltage (or 11.0 Volts for a 12 Volt battery, 22.0 Volts for a 24 Volt battery). Manufacturers may request approval to utilize a voltage threshold higher than this value to disable system monitoring. Approval of the request will be granted upon determining that the manufacturer has submitted data and/or an engineering evaluation that demonstrate that monitoring at the voltages would be unreliable and that either operation of a vehicle below the disablement criteria for extended periods of time is unlikely or the OBD system monitors the battery or system voltage and will detect a malfunction at the voltage used to disable other monitors.

5.2.4.2. *High voltage*

For monitoring systems affected by high vehicle battery or system voltages, manufacturers may request approval to disable monitoring systems when the battery or system voltage exceeds a manufacturer-defined voltage. Approval of the request will be granted upon determining that the manufacturer has submitted data and/or an engineering evaluation that demonstrate that monitoring above the manufacturer-defined voltage would be unreliable and that either the electrical charging system/alternator warning light is illuminated (or voltage gauge is in the "red zone") or the OBD system monitors the battery or system voltage and will detect a malfunction at the voltage used to disable other monitors.

5.2.5. *active PTO*

A manufacturer may disable affected monitoring systems in vehicles designed to accommodate the installation of PTO, provided disablement occurs only while the PTO unit is active, and the OBD readiness status is cleared by the on-board computer (i.e., all monitors set to indicate "not complete") while the PTO unit is activated. If the disablement occurs, the readiness status may be restored to its state prior to PTO activation when the disablement ends

6. Demonstration requirements

The complete demonstration process of an OBD system shall consist of the following phases (see chart n°1)

- The parent engine system representative of an emission OBD family is selected in agreement with the authorities. It will be subject to the complete demonstration process.
- The manufacturer submits to the authority the classification of each failure for that parent engine system and the necessary supporting data in order to justify each classification. The authority may require additional data or demonstration tests. The manufacturer conducts the requested applicable classification demonstration test.
- When required by the authority, the manufacturer shall provide deteriorated components for OBD testing purposes. The authority qualifies these components on the basis of supporting data provided by the manufacturer and may require emission testing to complete the qualification.
- The engine system is equipped with the qualified deteriorated component and tested on an engine test-bed to demonstrate the proper detection of the malfunction by the OBD system.

6.1. *Emission-OBD family*

The manufacturer is responsible for determining the composition of an emission-OBD family.
Grouping engine systems within an Emission-OBD family shall be based on good engineering judgement and be subject to approval by the authority.

Engines that do not belong to the same engine family may still belong to the same Emission-OBD family.

6.1.1. *Parameters defining an Emission-OBD family*

The Emission-OBD family may be defined by basic design parameters that shall be common to engine systems within the family.
In order that engine systems may be considered to belong to the same OBD-

engine family, the following list of basic parameters must be common,

- the methods of OBD monitoring,
- the methods of malfunction detection,

unless these methods have been shown as equivalent by the manufacturer by means of relevant engineering demonstration or other appropriate procedures.

Note: WWH-OBD to consider whether the above statements are sufficient to require that in the same OBD family, engine systems must have similar emission control architectures (i.e., they should have similar aftertreatment devices).

It is understood there may be minor differences in the methods of monitoring / diagnosing the engine emission control system due to engine system configuration variation:

- Methods may be considered as common if they differ only to match specificities of the considered components (e.g. size, exhaust flow, etc....)
- Other methods may be considered as common if based on good engineering judgement and approved by the certification authorities.

6.1.2. Parent engine system of an Emission-OBD family

The compliance of an Emission-OBD family to the requirements of this GTR may be achieved by demonstrating the compliance of the parent engine system of this family.

The selection of the parent engine is made by the manufacturer and subject to the approval of the authority.

6.2. Demonstration of the failure classification

The manufacturer shall present the documentation justifying the proper classification of each DTC. The documentation shall include a failure analysis (for example elements of a "failure mode and effect analysis"). This documentation could also include for instance:

- simulation results
- test results
- reference to previously approved classification, ….

6.2.1. Demonstration of classification into A

The classification by the manufacturer of a failure into class A shall not be subject to a demonstration test.

If the authority disagrees with a manufacturer classification of a failure as class A, the authority may demand reclassification of that failure into class B1, B2 or C, as appropriate.

In that case the certification document shall record that the failure classification has been done under request of the authority.

6.2.2. Demonstration of classification into B1 (Distinguishing between A and B1)

In order to justify the classification of a failure into class B1 the documentation shall clearly show that in some circumstances emissions in the case of such a failure are lower than the OTLs.
Some examples of such circumstances that will influence if and when OTLs may be exceeded are the age of the engine system or whether the test is

conducted with a new or aged component.

In case the authority is requesting an emission test for demonstrating the classification of a failure into class B1 the manufacturer may be requested to shall demonstrate that the emissions due to the failure are in some circumstances below the OTL.:

- the manufacturer selects these circumstances of test in agreement with the authority
- the manufacturer does not need to demonstrate that in other circumstances the emissions due to the failure are actually above the OTL.

If the manufacturer fails in demonstrating the classification as class B1, the failure is classified as class A.

6.2.3. Demonstration of classification into B1 (Distinguishing between B2 and B1)

If the authority disagrees with a manufacturers classification of a failure as class B1, because they consider the OTLs are not exceeded, the authority may demand reclassification of that failure into class B2 or C. In that case the certification documents shall record that the failure classification has been done under request of the authority.

6.2.4. Demonstration of classification into B2 (Distinguishing between B2 and B1)

In order to justify the classification of a failure into class B2 the manufacturer shall show that emissions are lower than the OTLs.
In case the authority disagrees with the classification of a failure as class B2, because they consider the OTLs are exceeded, the manufacturer may be requested to demonstrate by testing that the emissions due to the failure are below the OTLs.
If the test fails, then the authority shall request reclassification of that failure into A or B1 and the manufacturer shall subsequently demonstrate the appropriate reclassification and the documentation be updated.

6.2.5. Demonstration of classification into B2 (Distinguishing between B2 and C)

If the authority disagrees with a manufacturers classification of a failure as class B2, because they consider the emission limits are not exceeded, the authority may demand reclassification of that failure into class C. In that case the certification documents shall record that the failure classification has been done under request of the authority.

6.2.6. Demonstration of classification into C

In order to justify the classification of a failure into class C the manufacturer shall show that emissions are lower than the regulated emission limits.
In case the authority disagrees with the classification of a failure as class C the manufacturer may be requested to demonstrate by testing that the emissions due to the failure are below the regulated emission limits.
If the test fails, then the authority shall request reclassification of that failure and the manufacturer shall subsequently demonstrate the appropriate reclassification and the documentation be updated.

6.3. Demonstration of the OBD performance

The manufacturer shall submit to the authority a complete documentation justifying the compliance of the OBD system as regards its monitoring capability.
This documentation shall include, for instance:
- algorithms and decision charts
- tests and/or simulation results
- reference to previously approved monitoring systems, etc…

6.3.1. demonstration of the OBD performance by testing

In addition to the supporting data referred to in section 6.3, the authority may require the manufacturer to demonstrate the proper monitoring of specific emission control systems or components by testing them on an engine test-bed according to the test procedures specified in section 7.2 of this module.

In that case, the manufacturer shall make available the deteriorated components to be used to simulate a malfunction.
The proper detection of the malfunction by the OBD system and its proper response to that detection (cf. MI indication, fault code storage, etc) shall be demonstrated according to section 7.2

6.3.2. Qualification of deteriorated components

This section applies to the cases where the malfunction selected for an OBD demonstration test is monitored against tail pipe emissions (see section 4.1), and the authority requests the manufacturer to demonstrate by an emission test that the deteriorated component provided for that test is qualified.

Note: this section should be reviewed by WWH-OBD in order to avoid any possible misunderstanding concerning the qualification of failures belonging to other categories than category 1.

In very specific cases the qualification by testing may not be possible (for example, if a limp home strategy is activated, if the engine cannot run any test, etc…). In such cases, the deteriorated component is qualified. This exception shall be documented by the manufacturer and is subject to the agreement of the authority.

6.3.2.1. Qualification of deteriorated components used to demonstrate the detection of classes A and B1 failures

In the case the failure selected by the authority results in tailpipe emissions that may exceed an OBD threshold limit, the manufacturer shall demonstrate by an emission test according to section 7 that the deteriorated component or device does not lead the emissions to exceed this OTL by more than 20%.

6.3.2.2. Qualification of deteriorated components used to demonstrate the detection of class B2 failures

In the case of class B2 failures, and upon request of the authority, the manufacturer shall demonstrate by an emission test according to section 7 that the deteriorated component or device does not lead the emissions to exceed the applicable OTL.

6.3.2.3. Qualification of deteriorated components used to demonstrate the detection of class C failures

In the case of class C failures, and upon request of the authority, the manufacturer shall demonstrate by an emission test according to section 7 that the deteriorated component or device does not lead the emissions to exceed the applicable emission limit.

6.3.3. Test Protocol

6.4. Certification of an OBD system containing deficiencies

A manufacturer may request to the authority that an OBD system be accepted for certification even though the system contains one or more deficiencies such that the specific requirements of this module are not fully met.

In considering the request, the authority shall determine whether compliance with the requirements of this Module is feasible or unreasonable.
The authority shall take into consideration data from the manufacturer that details such factors as, but not limited to, technical feasibility, lead time and production cycles including phase-in or phase-out of engines designs and programmed upgrades of computers, the extend to which the resultant OBD system will be effective in complying with the requirements of this gtr and that the manufacturer has demonstrated an acceptable level of effort toward meeting the requirements of the gtr.

The authority will not accept any deficiency request that includes the complete lack of a required diagnostic monitor.

The authority shall not accept any deficiency request that does not respect the OBD threshold limits given in the table in section sss of this GTR.

In determining the identified order of deficiencies, deficiencies in respect of sections xxx to yyy of this Annex shall be identified first.

Prior to or at the time of certification, no deficiency shall be granted in respect of the requirements of sections zzz of this module.

6.4.1. Deficiency period

A deficiency may be carried-over for a period of two years after the date of certification of the engine system, unless it can be adequately demonstrated that substantial engine modifications and additional lead-time beyond two years would be necessary to correct the deficiency. In such a case, the deficiency may be carried-out for a period not exceeding three years.

A manufacturer may request that the original authority grant a deficiency retrospectively when such a deficiency is discovered after the original certification. In this case, the deficiency may be carried-over for a period of two years after the date of notification to the authority unless it can be adequately demonstrated that substantial engine modifications and additional lead-time beyond two years would be necessary to correct the deficiency. In such a case, the deficiency may be carried-out for a period not exceeding three years.

7. Test procedures

7.1. Testing process

The demonstration by testing of the proper failure classification and the demonstration by testing of the proper monitoring performance of an OBD system are issues that shall be considered separately. (For example, a class A failure will not require a classification test, while it may be subject to an OBD performance test).

Where appropriate, the same test may be used to demonstrate the correct classification of a failure, the qualification of a deteriorated component provided by the manufacturer, and the correct monitoring by the OBD system.

7.1.1. Testing process for demonstrating the failure classification

When, according to sections 6.2, the authority requests the manufacturer to justify by testing the classification of a specific failure, the compliance demonstration will consist of a series of emission tests.

According to section 6.2.2, when testing is required by the authority to justify the classification of a failure into class B1 rather than in class A, the manufacturer shall demonstrate that the emissions due to the failure are in some circumstances below the OTL.:

- the manufacturer selects these circumstances of test in agreement with the authority
- the manufacturer does not need to demonstrate that in other circumstances the emissions due to the failure are actually above the OTL.

The emission test may be repeated upon request of the manufacturer up to three times.
If any of these tests leads to emissions below the considered OTL, then the failure classification into class B1 is approved.

When testing is required by the authority to justify the classification of a failure into class B2 rather than in class B1 or into class C rather than in class B2, the emission test shall not be repeated. If the emissions measured in the test are above the OTL or the emission limit, respectively, then the failure needs reclassification.

Note: according to section 6.2.1, this section does not apply to failures classified into class A.

7.1.2. Testing process for demonstrating the OBD performance

When the authority requests according to section 6.3 to test the OBD system performance, the compliance demonstration shall consist of the following phases (see chart 2):

- a malfunction is selected by the authority and a corresponding deteriorated component or system shall be made available by the manufacturer
- when appropriate and if requested, the manufacturer shall demonstrate by an emission test that the deteriorated component is qualified for a monitoring demonstration
- the manufacturer shall demonstrate that the OBD system responds in a manner that complies with the provisions of this GTR (i.e. MI indication, fault code storage, etc…) at the latest by the end of a series of OBD test-cycles.

7.1.2.1. Qualification of the deteriorated component

When the authority requests the manufacturer to qualify a deteriorated component by testing according to sections 6.3.2, this demonstration shall be made by performing an emission test.

If it is determined that the installation of a deteriorated component or device on an engine system means that a comparison with the OBD threshold limits is not possible (e.g. because the statistical conditions for validating the applicable emission test cycle are not met), the failure of that component or device may be considered as qualified upon the agreement of the authority based on technical

rationale provided by the manufacturer.

In the case that the installation of a deteriorated component or device on an engine means that the full load curve (as determined with a correctly operating engine) cannot (even partially) be attained during the test, the deteriorated component or device may be considered as qualified upon the agreement of the authority based on technical rationale provided by the manufacturer.

7.1.2.2. Failure detection

Each monitor selected by the authority to be tested on an engine test-bed, shall respond to the introduction of a qualified deteriorated component in an that meets the requirements of this gtr within two consecutive OBD test-cycles according to section 7.2.2 of this module.

When it has been specified in the monitoring description and agreed by the authority that a specific monitor needs more than two operating sequences to achieve a proper monitoring, the number of OBD test-cycles may be increased accordingly.

Each individual OBD test-cycle in the demonstration test shall be separated by an engine shut-off. The time until the next start-up shall take into consideration any monitoring that may occur after engine shut-off and any necessary condition that must exist for monitoring to occur at the next start up.

The test may be considered complete as soon as the OBD system has responded in the that meets the requirements of this gtr.

7.2. Applicable tests

The emission test is the test-cycle used when emissions must be measured
The OBD test-cycle is the test-cycle used when evaluating the performance of the OBD monitor.
In many case these test-cycles are the same.

7.2.1. Emission Test cycle

The World Harmonised test-cycle considered in this module for measuring emissions is the transient portion (WHTC test-cycle) of the World harmonised Heavy duty emission test-Cycle (WHDC).
Note: Hot start or cold start to be decided (when applicable) in September.

When the engine-system has been certified to exhaust emissions limits measured over a test-cycle other than the WHDC and with the agreement of the authority, the emission test-cycle required within section 6 and referred to in section 7 will be the EU, Japanese, or US test-cycle(s) applicable for emission measurement for OBD purposes.

7.2.2. OBD Test cycle

The World Harmonised OBD test-cycle considered in this module is the transient portion (WHTC test-cycle) of the World harmonised Heavy duty emission test-Cycle (WHDC).
Note: Hot start or cold start to be decided (when applicable) in September.

When the engine-system has been certified to exhaust emissions limits measured over a test-cycle other than the WHDC and with the agreement of the authority, the OBD test-cycle may consist of the regionally accepted corresponding OBD test-cycles.

Manufacturers may request approval to use an alternative OBD test-cycle to the applicable test-cycles mentioned in this section. The request shall contain elements (technical considerations, simulation, or test results, etc..) demonstrating:

- the requested test-cycle results in a monitor that will run in real world driving, and
- the applicable World Harmonised or regionally accepted OBD test-cycle is shown to be less appropriate for the considered monitoring (e.g. fluid consumption monitoring).

7.2.3. Test operating conditions

The conditions for conducting the tests referred to in sections 7.2.1 and 7.2.2 (of temperature, altitude, fuel quality, etc…) shall be those required for operating the World-wide Heavy Duty emission test-Cycle (WHDC) in the "WHDC" GTR.

When the engine-system has been certified to exhaust emissions limits measured over a test-cycle other than the WHDC, the conditions for conducting the tests referred to in sections 7.2.1 and 7.2.2 are the conditions required for operating the applicable regionally accepted emission test-cycle.

In the case of an emission test aimed at justifying the classification of a specific failure into class B1, the test operating conditions may deviate from the ones in the paragraphs above according to section 6.2.2.

7.3. Test Protocols

8. Documentation requirements

8.1. documentation for purpose of certification

The manufacturer shall provide a documentation package that includes a full description of the OBD system. The documentation package shall be made available in two parts:

a- A primary documentation package, which may be brief, provided that it exhibits evidence concerning the relationships between monitors, sensors/actuators, and operating conditions (i.e. describes all enable conditions for monitors to run and disable conditions that cause monitors not to run). The documentation shall describe the functional operation of the OBD and outline each monitoring strategy and the decision process, including the failure ranking within the hierarchical classification.

This material shall be retained by the Authority. This information may be made available to interested parties upon request.

b- A secondary documentation package containing any data, including details of qualified deteriorated components or systems and associated test results, which are used as evidence to support the decision process referred to above, and a listing of all input and output signals that are available to the control system that is to be monitored by the OBD system, whether or not the individual signal is monitored by the OBD.

This additional material shall remain strictly confidential and [at the discretion of the authority] may be retained by the manufacturer but shall be made open for inspection by the Authority at the time of certification

or at any time during the validity of an approval.

8.1.1. documentation associated with each monitored component or system

A table shall include the following information for each monitored component or system

(a) the malfunctions and associated fault code(s)
(b) the monitoring method used for malfunction detection
(c) the parameters used for malfunction detection and when applicable the fault criteria limits and/or OBD thresholds
(d) the criteria for storing a fault code

8.1.2. documentation associated with each fault code

For each fault code the information shall include but will not be limited to:

- the monitoring method or procedure for malfunction
- primary malfunction detection and its type of output signal (to be re-formulated in the text)
- fault criteria limits used to evaluate output signal of primary parameter
- other monitored secondary parameters and conditions necessary for malfunction detection
- the monitoring "time length" (operation time/procedure necessary to complete the monitoring) and "frequency" of checks (e.g. continuous, once per trip, etc…)
- the criteria for storing fault code
- the criteria for illuminating malfunction indicator light (i.e. pending, confirmed issue)
- the criteria used for determining out of range values and input component rationality checks

These elements shall be common within an emission-OBD family, although different calibration may be allowed.

8.1.3. documentation associated with the failure classification

The failure classification of each fault code shall be documented. This classification may be different for different engine types within the same OBD engine family

This information shall include the technical justification required in section 4.2 of this module for classification into class A, class B1 or class B2

8.1.4. documentation associated with the OBD engine family

A description of the OBD Engine family shall be provided. This description shall include a list and a description of the engine types within the family, the description of the "parent engine", and all elements that characterize the family according to section 5.1 of this module.

In the case the OBD engine family includes engines belonging to different engine families, a summary description of these engine families shall be provided.

-In addition, the manufacturer shall provide a list of all electronic input and output signals (with the exception of those not monitored by the OBD system), an identification of the communication protocol utilized by each OBD family.

8.2. Documentation for installing in a vehicle an OBD equipped engine system

The engine manufacturer shall include in the installation documents of its engine system the appropriate requirements that will ensure the vehicle on the road to comply with the requirements of this GTR. This documentation shall include but is not limited to:

- the detailed technical requirements, including the provisions ensuring the compatibility with the OBD system of the engine system
- the verification procedure to be completed

The existence and the adequacy of such installation requirements may be checked during the certification process of the engine system.

9. Annexes

ANNEX 1 *Direct certification of a vehicle equipped with an Emission-OBD system*

This section considers the case the vehicle manufacturer directly applies for a certification of the complete vehicle Emission-OBD system instead of applying for both a certification of the engine-system and a certification of its installation.

The vehicle manufacturer is then responsible for the complete Emission-OBD system, including of the OBD elements mounted on-board the vehicle that are not part of the engine-system and for the proper installation of engine system as regards its OBD system (cf. interface compatibility)

In this case, and in addition to the general requirements of this module, a demonstration of the correct installation may be required. This demonstration shall be done on the basis of appropriate element of design, results of verification tests, etc...and address the conformity of the following elements to the requirements of this GTR:

- the installation on-board the vehicle as regards its compatibility with the OBD system of the engine-system.
- the MI and, where appropriate, the additional warning modes;
- when applicable, the wired communication interface.
- when applicable, the wireless communication interface.

In some specific cases the authority may also estimate necessary to proceed to an additional experimental verification. In that case one simple failure mode, such as an electric disconnection is selected by the authority. Correct MI illumination, information storage, and on-board off-board OBD communication are checked.

ANNEX 2 MI de-activation process and MI-counter erasing (examples)

ANNEX 3 *Recommendations for monitoring subsystems*

Appendix 1. Diesel Particulate Filter (DPF), or Particulate Matter Trap
The OBD system shall monitor the DPF system on engines so-equipped for proper performance. Individually monitored elements of the DPF system and any malfunction(s) therein shall include, where equipped, the following:

- The OBD system shall monitor the PM trapping efficiency against total functional failure.
- Any electric / electronic component of the DPF system shall be monitored according the requirements for comprehensive components.

Appendix 2. Lean-NOx Trap (LNT), or NOx Adsorber
The OBD system shall monitor the LNT system on engines so-equipped for proper performance. Individually monitored elements of the LNT system and any malfunction(s) therein shall include, where equipped, the following:

- The OBD system shall monitor the NOx trapping and conversion efficiency against total functional failure.
- Depending on the availability of robust and durable exhaust emission sensors the trapping and regeneration efficiency shall be monitored against emission thresholds which take into account the measuring accuracy of the sensors.
- Any electric / electronic component of the LNT system shall be monitored according the requirements for comprehensive components.

Appendix 3. Selective Catalytic Reduction System (SCR)
The OBD system shall monitor the SCR system on engines so-equipped for proper performance. Individually monitored elements of the SCR system and any malfunction(s) therein shall include, where equipped, the following:

- The OBD system shall monitor the NOx conversion efficiency of the catalyst against total functional failure.
- The OBD system shall monitor the reductant delivery system against total functional failure.
- The OBD system shall monitor the reductant quality against total functional failure.
- Depending on the availability of robust and durable exhaust emission sensors the NOx conversion efficiency of the complete SCR system shall be monitored against emission thresholds which take into account the measuring accuracy of the sensors.
- Any electric / electronic component of the SCR system shall be monitored according the requirements for comprehensive components.

Appendix 4. Diesel Oxidation Catalyst (DOC)
The OBD system shall monitor the DOC system on engines so-equipped for proper performance if the DOC is situated upstream of Nox or PM aftertreatment. Individually monitored elements of the DOC and any malfunction(s) therein shall include, where equipped, the following:

- The OBD system shall detect if the DOC shows no NMHC conversion efficiency.

Appendix 5. Exhaust Gas Recirculation (EGR) System Monitoring
The OBD system shall monitor the EGR system on engines so-equipped for proper performance. Individually monitored elements of the EGR system and any malfunction(s) therein shall include, where equipped, the following:

- The OBD system shall detect, if the EGR system is not able to achieve the commanded EGR flow rate. This malfunction shall be monitored against the OBD thresholds.
- Any electric / electronic component of the EGR system shall be monitored according the requirements for comprehensive components.

Appendix 6. Fuel System Monitoring
The OBD system shall monitor the fuel system on engines so-equipped for proper performance. Individually monitored elements of the fuel system and

any malfunction(s) therein shall include, where equipped, the following:

- The OBD system shall detect, if the fuel system is not able to achieve the commanded fuel pressure in closed loop control. This malfunction shall be monitored against the OBD thresholds.
- Any electric / electronic component of the fuel system shall be monitored according the requirements for comprehensive components.

Appendix 7. Air Handling and Turbocharger/Boost Pressure Control System
The OBD system shall monitor the air handling system on engines so-equipped for proper performance. Individually monitored elements of the air handling system and any malfunction(s) therein shall include, where equipped, the following:

- The OBD system shall detect, if the air handling system is not able to achieve the commanded boost. This malfunction shall be monitored against the OBD thresholds.
- The OBD system shall monitor the charge air cooling system efficiency against total functional failure.
- Any electric / electronic component of the air handling system shall be monitored according the requirements for comprehensive components.

Appendix 8. Variable Valve Timing (VVT) System
The OBD system shall monitor the VVT system on engines so-equipped for proper performance. Individually monitored elements of the VVT system and any malfunction(s) therein shall include, where equipped, the following:

- The OBD system shall detect target errors. These malfunctions shall be monitored against the OBD thresholds.
- Any electric / electronic component of the VVT system shall be monitored according the requirements for comprehensive components.

Appendix 9. Crankcase Ventilation System Monitoring
The OBD system shall monitor the crankcase ventilation system on engines so-equipped through functional checks. Individually monitored elements of the crankcase ventilation system and any malfunction(s) therein shall include, where equipped, the following:

- Any disconnections that occur between the crankcase and the intake manifold except where such disconnection is very unlikely (e.g., a valve installed directly on the crankcase rather than connected to the crankcase via a tube).

Note: WWH-OBD shall review the above monitoring requirements by taking into consideration document 16_05_02 from the Bonn meeting that says:

"1.1 Threshold Monitors

Each of the following monitoring requirements shall be met by employing one or more of the following types of monitoring strategies:

- Direct emissions measurement via a tailpipe emissions sensor(s); and/or
- Indication of an emissions increase via correlation of computer input/output information to actual emissions. This correlation would typically be done on a test engine in a laboratory setting.

Diesel Particulate Filter (DPF), or Particulate Matter Trap, System Monitoring
The OBD system shall monitor the DPF system on engines so-equipped for proper performance and shall identify any malfunction(s) according to the failure hierarchy described in section 5.2. Individually monitored elements of the DPF system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- - Particulate matter (PM) trapping.
- - Regeneration of trapped PM, including the ability to achieve proper regeneration temperatures, regeneration at insufficient frequencies, and regeneration at excessive frequencies.
- - Chemical oxidation of regulated emissions (e.g., carbon monoxide,

hydrocarbons, etc.).

Lean-NOx Trap (LNT), or NOx Adsorber, System Monitoring
The OBD system shall monitor the LNT system on engines so-equipped for proper performance and shall identify any malfunction(s) according to the failure hierarchy described in section 5.2. Individually monitored elements of the LNT system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- NOx trapping.
- Regeneration and chemical conversion of trapped NOx to a non-regulated emission.
- Chemical oxidation of regulated emissions (e.g., carbon monoxide, hydrocarbons, etc.).

Selective Catalytic Reduction (SCR) System Monitoring
The OBD system shall monitor the SCR system on engines so-equipped for proper performance and shall identify any malfunction(s) according to the failure hierarchy described in section 5.2. Individually monitored elements of the SCR system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- Chemical reduction of NOx emissions to a non-regulated emission.
- Chemical oxidation of regulated emissions (e.g., carbon monoxide, hydrocarbons, etc.).

Diesel Oxidation Catalyst (DOC) System Monitoring
The OBD system shall monitor the DOC system on engines so-equipped for proper performance and shall identify any malfunction(s) according to the failure hierarchy described in section 5.2. Individually monitored elements of the DOC system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- Chemical oxidation of regulated emissions (e.g., carbon monoxide, hydrocarbons, etc.).

Exhaust Gas Recirculation (EGR) System Monitoring
The OBD system shall monitor the EGR system on engines so-equipped for proper performance and shall identify any malfunction(s) according to the failure hierarchy described in section 5.2. Individually monitored elements of the EGR system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- Achieving the commanded EGR flow rate including both the inability to increase EGR flow and/or to reduce EGR flow when unable to reach the commanded flow rate.
- Responding to changes in commanded EGR flow rates within manufacturer specified time limits.
- Undercooling/overcooling the EGR flow to the commanded level.

Fuel System Monitoring
The OBD system shall monitor the fuel system on engines so-equipped for proper performance and shall identify any malfunction(s) according to the failure hierarchy described in section 5.2. Individually monitored elements of the fuel system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- Achieving the commanded fuel pressure.
- Achieving the commanded fuel quantity.
- Achieving the commanded fuel timing.
- Ability to maintain closed-loop control.

Air Handling and Turbocharger/Boost Pressure Control System Monitoring
The OBD system shall monitor the air handling system on engines so-equipped for proper performance and shall identify any malfunction(s) according to the failure hierarchy described in section 5.2. Individually monitored elements of the air handling system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- Underboost conditions.
- Overboost conditions.

- Slow boost response rate conditions.
- Charge air undercooling.
- Charge air overcooling.
- Charge air cooling/heating used as part of a cold engine starting strategy.

Variable Valve Timing (VVT) System Monitoring
The OBD system shall monitor the VVT system on engines so-equipped for proper performance and shall identify any malfunction(s) according to the failure hierarchy described in section 5.2. Individually monitored elements of the VVT system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- Achieving the commanded valve timing.
- Slow response to commanded changes in valve timing.

Misfire Monitoring

- The OBD system shall detect engine misfire and shall classify when the percentage of misfiring combustion events exceeds the percentages that would cause emissions at the levels specified in the failure hierarchy described in section 5.2.

1.2 Comprehensive Component Monitors

The OBD system shall monitor any electronic component/system not otherwise described in section 1 that either provides input to (directly or indirectly) or receives commands from the on-board computer(s), and: (1) can affect emissions during any reasonable in-use driving condition, or (2) is used as part of the diagnostic strategy for any other monitored system or component.

Each of the following monitoring requirements shall be met by employing at least one and preferably more of the following types of monitoring strategies:

- Functionality monitor
- Rationality monitor
- Electrical circuit continuity monitor
- Out-of-range monitor

For input components/systems, the OBD system shall detect malfunctions caused by a lack of circuit continuity, out-of-range values, and, where feasible, rationality faults. To the extent feasible, the rationality fault diagnostics shall verify that a sensor output is neither inappropriately high nor inappropriately low (i.e., shall be “two-sided” diagnostics). Also to the extent feasible, the OBD system shall separately detect and store different fault codes that distinguish rationality faults from lack of circuit continuity and out-of-range faults and, to the extent feasible, separately detect and store different fault codes for each distinct malfunction (e.g., out-of-range low, out-of-range high, open circuit). The OBD system is not required to store separate fault codes for lack of circuit continuity faults that cannot be distinguished from other out-of-range circuit faults.

For output components/systems, the OBD system shall detect malfunctions when proper functional response to computer commands does not occur. If a functional check is not feasible, the OBD system shall detect malfunctions of output components/systems caused by a lack of circuit continuity or circuit fault (e.g., short to ground or high voltage). For output component lack of circuit continuity faults and circuit faults, the OBD system is not required to store different fault codes for each distinct malfunction (e.g., open circuit, shorted low).

Where comprehensive component monitoring strategies are employed, the manufacturer shall use good engineering judgement to determine the classification of any detected malfunctions according to the failure

hierarchy described in section 5.2. When a monitor detects a condition that would limit the ability of another OBD monitor to run (i.e., some other monitor cannot enter its enable conditions), a malfunction shall be identified and classified according to the failure hierarchy classification of the monitor that cannot be enabled, regardless of the expected emissions impact of the detected malfunction. In other words, if a malfunction classified by the manufacturer as Class A cannot be detected because the enable criteria for the monitor that would detect that malfunction cannot be met, the detected malfunction shall be treated as a Class A malfunction. Likewise, if the monitor that cannot be enabled is a Class B1 monitor, the detected malfunction shall be treated as Class B1.

The OBD system need monitor input or output components/systems associated with an electronic transfer case only if the transfer case component or system is used as part of the diagnostic strategy for any other monitored system or component.

Diesel Particulate Filter (DPF) System Monitoring
Individually monitored elements of the DPF system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- The pressure and/or temperature and/or exhaust gas sensors used in the control and/or diagnostic strategy of the DPF system.
- In-exhaust fuel injector(s) used for triggering DPF regeneration.
- In-exhaust burners or heating elements used for triggering DPF regeneration.

NOx Adsorber, or Lean NOx Trap (LNT), System Monitoring
Individually monitored elements of the LNT system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- The pressure and/or temperature and/or exhaust gas sensors used in the control and/or diagnostic strategy of the LNT system.
- In-exhaust fuel injector(s) used for triggering LNT regeneration.
- In-exhaust burners or heating elements used for triggering LNT regeneration.

Selective Catalytic Reduction (SCR) System Monitoring
Individually monitored elements of the SCR system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- The pressure and/or temperature and/or exhaust gas sensors used in the control and/or diagnostic strategy of the SCR system.
- In-exhaust fuel injector(s) used for delivering reductant.

Diesel Oxidation Catalyst (DOC) System Monitoring
Individually monitored elements of the DOC system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- The pressure and/or temperature and/or exhaust gas sensors used in the control and/or diagnostic strategy of the DOC system.
- In-exhaust fuel injector(s) used as part of the DOC system.
- In-exhaust burners or heating elements used as part of the DOC system.

Exhaust Gas Recirculation (EGR) System Monitoring
Individually monitored elements of the EGR system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- The pressure and/or temperature and/or exhaust gas sensors used in the control and/or diagnostic strategy of the EGR system.
- Ability to achieve the commanded EGR valve position.

Fuel System Monitoring
Individually monitored elements of the fuel system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- Ability to deliver commanded in-cylinder post-injection where used as part of the DPF and/or LNT and/or other exhaust aftertreatment device control strategy.
- Maintenance of proper feedback control.
- The pressure and/or temperature and/or exhaust gas sensors used in the control and/or diagnostic strategy of the fuel system.

Air Handling and Turbocharger/Boost Pressure Control System Monitoring
Individually monitored elements of the air handling system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- The pressure and/or temperature and/or exhaust gas sensors used in the control and/or diagnostic strategy of the air handling system.

Variable Valve Timing (VVT) System Monitoring
Individually monitored elements of the VVT system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- The pressure and/or temperature and/or exhaust gas sensors used in the control and/or diagnostic strategy of the VVT system.
- Proper functional response to computer commands.

Other Electronic Engine Control Computer Input or Output Components
The OBD system shall monitor any electronic input or output components not otherwise noted above that comprise the emission control system and/or the engine system for proper performance and shall identify any malfunction(s) according to the failure hierarchy described in section 5.2. Individually monitored elements and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- Sensors that provide input to the engine control computer.
- Actuators that receive outputs (commands) from the engine control computer.

1.3 Other Monitors

Each of the following monitoring requirements shall be met by employing one or more of the following types of monitoring strategies:

- Functionality monitor
- Rationality monitor
- Electrical circuit continuity monitor
- Out-of-range monitor

The manufacturer shall use good engineering judgement to determine the classification of any detected malfunctions according to the failure hierarchy described in section 5.2. When a monitor detects a condition that would limit the ability of another OBD monitor to run (i.e., some other monitor cannot enter its enable conditions), a malfunction shall be identified and classified according to the failure hierarchy classification of the monitor that cannot be enabled, regardless of the expected emissions impact of the detected malfunction. In other words, if a malfunction classified by the manufacturer as Class A cannot be detected because the enable criteria for the monitor that would detect that malfunction cannot be met, the detected malfunction shall be treated as a Class A malfunction. Likewise, if the monitor that cannot be enabled is a Class B1 monitor, the detected malfunction shall be treated as Class B1.

Engine Cooling System Monitoring
The OBD system shall monitor the engine cooling system for proper performance and shall identify any malfunction(s) according to the failure hierarchy described in section 5.2. Individually monitored elements of the engine cooling system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- The thermostat. This shall include monitoring for the ability to reach the highest temperature required to enable all other emission-related OBD monitors. This shall also include monitoring the ability of the

coolant temperature to reach a warmed-up temperature within a manufacturer defined "proper temperature range" within a manufacturer defined time limit. The time limit must be reached following every engine start that includes a minimum of 20 cumulative minutes of non-idle operation. Manufacturers need not monitor the thermostat if it can be shown that its failure will not cause any emissions increase or if its failure will not disable any other monitors.

- The engine coolant temperature (ECT) sensor. This shall include detecting when the ECT sensor does not achieve the highest stabilized minimum temperature needed for closed-loop/feedback control of all emission control systems (e.g., fuel system, EGR system) within a manufacturer defined time limit. The time limit must be reached following every engine start that includes a minimum of 20 cumulative minutes of non-idle operation. This shall also include detecting when the temperature readings by the ECT sensor inappropriately fail to lie within the enable criteria temperature range of any other OBD monitor. Manufacturers need not monitor the ECT sensor in temperature ranges where the temperature gauge indicates a temperature in the red zone (engine overheating zone) for vehicles that have a temperature gauge (not a warning light) on the instrument panel and utilize the same ECT sensor for input to the OBD system and the temperature gauge.
- The pressure and/or temperature and/or exhaust gas sensors used in the control and/or diagnostic strategy of the engine cooling system.

Reductant System Monitoring
This monitoring need be done only for systems using a reductant other than the fuel used to power the engine. Individually monitored elements of the reductant system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- Level of reductant in the reductant tank.
- Presence of the proper reductant in the reductant tank.
- In-exhaust delivery of the proper amount of reductant.

Crankcase Ventilation System Monitoring
The OBD system shall monitor the crankcase ventilation system on engines so-equipped for proper performance and shall identify any malfunction(s) according to the failure hierarchy described in section 5.2. Individually monitored elements of the crankcase ventilation system and any malfunction(s) therein shall include, where equipped, but not necessarily be limited to the following:

- Any disconnections that occur between the crankcase and the intake manifold except where such disconnection is very unlikely (i.e., a valve installed directly on the crankcase rather than connected to the crankcase via a tube).
- The pressure and/or temperature and/or exhaust gas sensors used in the control and/or diagnostic strategy of the closed crankcase system.

Idle Speed Control System
The idle speed control system shall be monitored for proper functional response to computer commands. For strategies based on deviation from target idle speed, a malfunction shall be detected when either of the following conditions occur:

- The idle speed control system cannot achieve the target idle speed with a fuel injection quantity within +/-50% of nominal injection quantity. Larger fuel injection quantity tolerances may be approved if the manufacturer can provide data and/or an engineering evaluation that demonstrate that the tolerances can be exceeded without a malfunction being present.
- The idle speed control system cannot achieve the target idle speed within the smallest engine speed or fuel injection quantity tolerance range required by the OBD system to enable any other monitors.

Glow Plugs and/or Intake Air Heater Systems
Glow plugs and intake air heater systems shall be monitored for proper functional response to computer commands and for circuit continuity faults. The glow plug/intake air heater circuit(s) shall be monitored for proper current and voltage drop. Other monitoring strategies may be

approved based on manufacturer's data and/or engineering analysis demonstrating equally reliable and timely detection of malfunctions. Unless otherwise approved, the OBD system shall detect a malfunction when a single glow plug no longer operates within the manufacturer's specified limits for normal operation. If a manufacturer demonstrates that a single glow plug failure cannot cause a measurable increase in emissions during any reasonable driving condition, the OBD system shall detect a malfunction for the minimum number of glow plugs needed to cause an emission increase. Further, to the extent feasible, the stored fault code shall identify the specific malfunctioning glow plug(s).

The wait-to-start lamp circuit and the MI circuit shall be monitored for malfunctions that cause them to fail to activate when commanded to."

ANNEX 4 Test protocol

Insert file named:
"WWH-OBD Testprotocol_GTR Draft_2005-05-22.doc"

Table of content