UNITED
NATIONS

Informal document No. GRPE-47-14
(47th GRPE, 12-16 January 2004,
agenda item 1.1.)

Worldwide Harmonised Heavy Duty Emissions Certification Procedure

[DRAFT GLOBAL TECHNICAL REGULATION (GTR)]

UN/ECE-WP 29 - GRPE
WHDC Working Group

Whilst this document is presented in the format of a draft GTR as defined by WP.29 / 883, the WHDC informal group / GRPE recognise that the issue of GTR's and specific performance requirements / limit values is still being considered. Accordingly, GRPE will finalise the document once WP.29 / AC.3 has reached a decision.

This document only covers the general structure of the final GTR procedure, as approved by the WHDC group at their 15th meeting on 21.05.2003, and does only contain a limited amount of technical details of the test procedure. The missing technical details will be added upon GRPE approval of the general structure, as herewith submitted.

Draft Version 08.01.2004

UNITED
NATIONS

E

Economic and Social Council

Distr.
GENERAL

TRANS/WP.29/xxx

Draft Version 08.01.2004

ENGLISH
Original: ENGLISH

ECONOMIC COMMISSION FOR EUROPE

INLAND TRANSPORT COMMITTEE

World Forum for Harmonisation of Vehicle Regulations (WP.29)

DRAFT GLOBAL TECHNICAL REGULATION (GTR)

UNIFORM PROVISIONS CONCERNING THE TEST PROCEDURE FOR COMPRESSION-IGNITION (C.I.) AND NATURAL GAS (NG) ENGINES AS WELL AS POSITIVE-IGNITION (P.I) ENGINES FUELLED WITH LIQUEFIED PETROLEUM GAS (LPG) AND VEHICLES EQUIPPED WITH C.I. AND NG ENGINES AND P.I. ENGINES FUELLED WITH LPG, WITH REGARD TO THE EMISSIONS OF POLLUTANTS BY THE ENGINE

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A. Statement of Technical Rationale and Justification

1. Technical and Economic Feasibility

The objective of this proposal is to establish a harmonised Global Technical Regulation (GTR) covering the type-approval procedure for heavy-duty engine exhaust emissions. The basis will be the test procedure developed by the WHDC informal group of GRPE (see final summary, [informal document no. 4] to the 46th GRPE).

Regulations governing the exhaust emissions from heavy-duty engines have been in existence for many years but the test cycles and methods of emissions measurement vary significantly. To be able to correctly determine the impact of a heavy-duty vehicle on the environment in terms of its exhaust pollutant emissions, a laboratory test procedure, and consequently the GTR, needs to be adequately representative of real-world vehicle operation.

The proposed regulation is based on new research into the world-wide pattern of real heavy commercial vehicle use. From the collected data, two representative test cycles, one transient test cycle (WHTC) and one steady state test cycle (WHSC), have been created covering typical driving conditions in the European Union, the United States of America and Japan. Alternative emission measurement procedures have been developed by an expert committee in ISO and have been published in ISO 16183. This standard reflects the state-of-the-art in exhaust emissions measurement technology with the potential for accurately measuring the pollutant emissions from future low emission engines.

The WHTC and WHSC test procedures reflect world-wide on-road heavy-duty engine operation as closely as possible and provide a marked improvement in the realism of the test procedure for measuring the emission performance of existing and future heavy-duty engines.

The performance levels (emissions test results) to be achieved in the GTR will be discussed on the basis of the most recently agreed legislation in the Contracting Parties, required by the 1998 Agreement. On the basis of heavy-duty engine emission measurements according to the procedures contained within this GTR, it will be possible to propose pollutant emission limit values that are compatible to existing or future limit values in different regions/countries.

2. Anticipated benefits

Compared to the measurement methods defined in existing legislation in Contracting Parties, the testing methods defined in this GTR are much more representative of in-use driving behaviour of commercial vehicles world-wide.

As a consequence, it can be expected that the application of this GTR for emissions legislation within the Contracting Parties will result in a higher control of in-use emissions due to the improved correlation of the test methods with in-use driving behaviour.

Additionally, heavy commercial vehicles and their engines are increasingly produced for the world market. It is economically inefficient for manufacturers to have to prepare substantially different models in order to meet different emission regulations and methods of measuring emissions, which, in principle, aim at achieving the same objective. To enable manufacturers to develop new models more effectively and within shorter time it is desirable that a GTR should be developed.

3. [Potential cost effectiveness]

Reserved. Not yet clear whether this chapter is requested or not.

B. Text of Regulation

1 Scope and Purpose

This regulation aims at providing a world-wide harmonised method for the determination of the levels of pollutant emissions from heavy-duty engine used in commercial vehicles in a manner which is representative of real world vehicle operation. The results can be the basis for the regulation of pollutant emissions indicated by the manufacturer within regional type-approval and certification procedures.

2 Application

This Regulation applies to the emission of gaseous and particulate pollutants from compression-ignition engines, natural gas engines and positive-ignition engines fuelled with LPG, used for propelling motor vehicles having a design speed exceeding 25 km/h and having a total mass exceeding 3.5 tonnes.

3 Definitions and Abbreviations

For the purposes of this Regulation,

To be added later

4 General Requirements

The components liable to affect the emission of gaseous and particulate pollutants shall be so designed, constructed and assembled as to enable the vehicle in normal use, despite the vibration to which it may be subjected, to comply with the provisions of this Regulation.

5 [Performance Requirements]

Reserved. Decision of AC.3 required.

This chapter will include limit values and general approval procedures, such as vehicle/engine categories, conformity of production provisions etc.

6 Test Conditions

6.1 Engine Test Conditions

6.2 Specification of Reference Fuel

The appropriate reference fuels as defined in Annex 10.3 must be used for testing.

6.3 Principals of Emissions Measurement

In this regulation, two measurement principles are described that are functionally equivalent:

- the gaseous components are measured in the raw exhaust gas on a real time basis, and the particulates are determined using a partial flow dilution system;
- the gaseous components and the particulates are determined using a full flow dilution system (CVS system).
- any combination of the two principles (e.g. raw gaseous measurement and full flow particulate measurement) is permitted.

6.4 Engine Family

The engine family, as determined by the engine manufacturer, may be defined by basic characteristics which must be common to engines within the family. In some cases there may be interaction of parameters. These effects must also be taken into consideration to ensure that only engines with similar exhaust emission characteristics are included within an engine family.

In order that engines may be considered to belong to the same engine family, the following list of basic parameters must be common:

To be added later. For details see ISO 16185

7 Test Procedures

The engine shall be subjected to the tests specified below.

7.1 Transient Test Cycle WHTC

The transient test cycle WHTC is listed in Annex 10.2 as a second-by second sequence of normalized speed and torque values applicable to all engines covered by this Standard. In order to perform the test on an engine test cell, the normalized values shall be converted to the actual values for the individual engine under test based on the engine mapping curve. The conversion is referred to as denormalization, and the test cycle so developed as the reference cycle of the engine to be tested. With those reference speed and torque values, the cycle shall be run on the test cell, and the feedback speed, torque and power values shall be recorded. In order to validate the test run, a regression analysis between reference and feedback speed, torque and power values shall be conducted upon completion of the test. For calculation of the brake specific emissions, the actual cycle work shall be calculated by integrating actual engine power over the cycle. For cycle validation, the actual cycle work must be within prescribed limits of the cycle work of the reference cycle (reference cycle work).

The WHTC is shown schematically in figure 1.

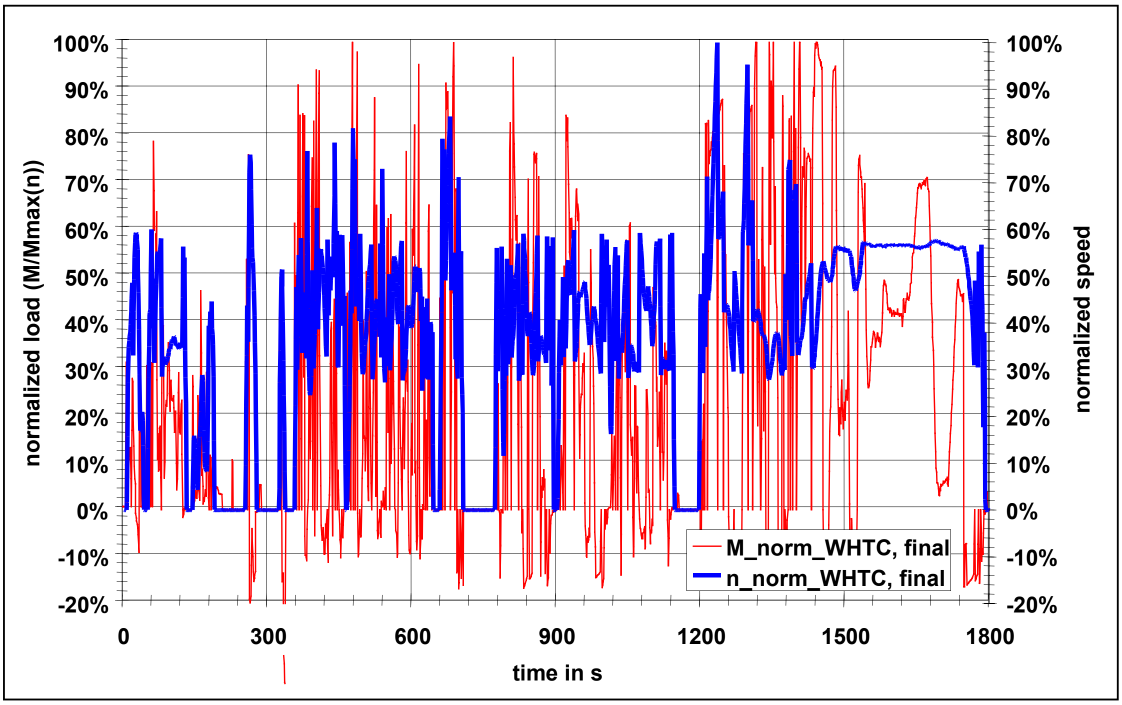

Figure 1 WHTC test cycle

7.2 Steady State Test Cycle WHSC

The steady state test cycle WHSC consists of a number of speed and power modes which cover the typical operating range of heavy duty engines. During each mode the concentration of each gaseous pollutant, exhaust flow and power output shall be determined, and the measured values weighted. The particulate sample shall be diluted with conditioned ambient air. One sample over the complete test procedure shall be taken, and collected on suitable filters.

The WHSC is shown schematically in figure 2.

Basis:	Total PM sampling time close to WHTC = 1520 sec					
	Mode length dependent on WF (J13 procedure proposed by Mr. Schweizer)					
	Mode stabilization time = 30 sec					
	Idle mode determines length of other modes due to the highest WF (ca. 5,7 minutes)					
	Total cycle length is 31.3 minutes					
	Motoring is accounted for mathematically by a WF of 0.24 and zero emissions/zero power)					
	Motoring does not add to sample time, mode length and cycle length					
Mode No	Speed [%]	Load [%]	WF	Sample time [s]	Mode length [s]	
0	Motoring		24%			
1	0	0	17%	340	370	
2	55	100	2%	40	70	
3	55	25	10%	200	230	
4	55	70	3%	60	90	
5	35	100	2%	40	70	
6	25	25	8%	160	190	
7	45	70	3%	60	90	
8	45	25	6%	120	150	
9	55	50	5%	100	130	
10	75	100	2%	40	70	
11	35	50	8%	160	190	
12	35	25	10%	200	230	
Sum			100%	1520	1880	

Figure 2 WHSC test cycle

7.3 Engine Mapping Procedure

7.4 Test Cycle Generation

7.5 Emissions Test Run

The emissions to be measured from the exhaust of the engine include the gaseous components (carbon monoxide, total hydrocarbons or non-methane hydrocarbons and oxides of nitrogen), and the particulates. Additionally, carbon dioxide is often used as a tracer gas for determining the dilution ratio of partial and full flow dilution systems.

The above pollutants shall be examined during the prescribed test cycles. Using the engine torque and speed feedback signals of the engine dynamometer, the power shall be integrated with respect to time of the cycle resulting in the work produced by the engine over the cycle. The concentrations of the gaseous components shall be determined over the cycle either in the raw exhaust gas by integration of the analyzer signal, or in the diluted exhaust gas of a CVS full flow dilution system by integration or by bag sampling. For particulates, a proportional sample shall be collected from the diluted exhaust gas on a specified filter by either partial flow dilution or full flow dilution. Depending on the method used, the diluted or undiluted exhaust gas flow rate shall be determined over the cycle to calculate the mass emission values of the pollutants. The mass emission values shall be related to the engine work to get the grams of each pollutant emitted per kilowatt hour.

8 Emissions Measurement and Calculation

8.1 Partial Flow Dilution (PFS) and Raw Gaseous Measurement

The instantaneous concentration signals of the gaseous components are used for the calculation of the mass emissions by multiplication with the instantaneous exhaust mass flow rate. The exhaust mass flow rate may be measured directly, or calculated using the methods of intake air and fuel flow measurement, tracer method or intake air and air/fuel ratio measurement. Special attention shall be paid to the reponse times of the different instruments. These differences shall be accounted for by time aligning the signals.

For particulates, the exhaust mass flow rate signals are used for controlling the partial flow dilution system to take a sample proportional to the exhaust mass flow rate. The quality of proportionality is checked by applying a regression analysis between sample and exhaust flow.

The complete test set up is schematically shown in figure 3.

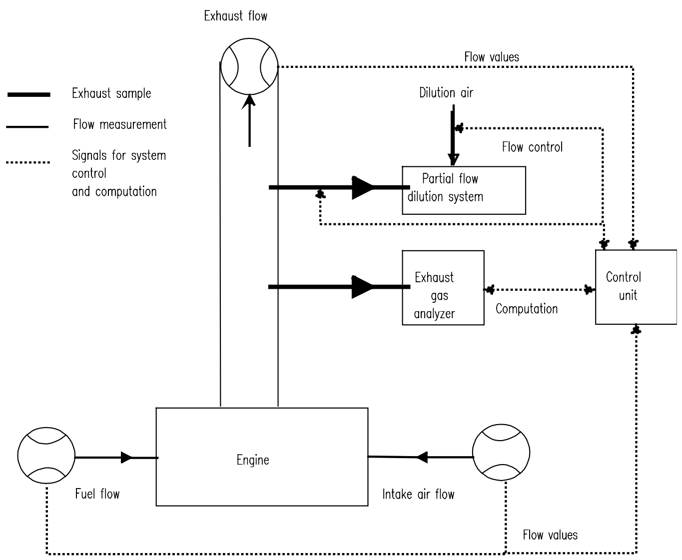

Figure 3 Schematic of raw/partial flow measurement system

8.2 Full Flow Dilution Measurement (CVS)

The concentration signals, either by integration over the cycle or by bag sampling, of the gaseous components shall be used for the calculation of the mass emissions by multiplication with the diluted exhaust mass flow rate. The exhaust mass flow rate shall be measured with a constant volume sampling (CVS) system, which may use a positive displacement pump (PDP), a critical flow venturi (CFV) or a subsonic venturi (SSV).

For particulates, a proportional sample is taken from the diluted exhaust gas of the CVS system.

The complete test set up is schematically shown in figure 4.

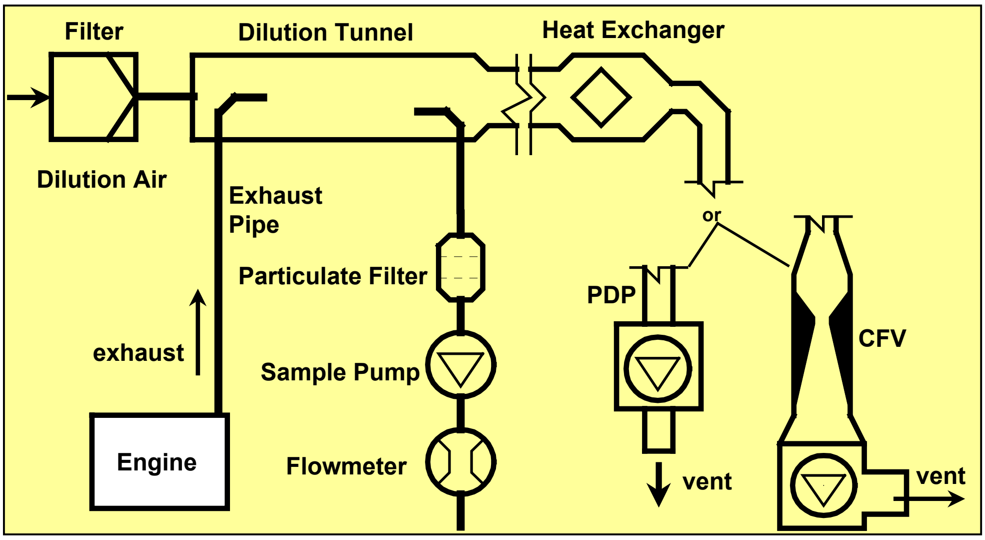

Figure 4 Schematic of CVS full flow dilution system

9 Emissions Measurement Equipment

9.1 Gaseous Emissions Measurement and Sampling System

To be added later. For details see ISO 16183, US CFR Part 86, ECE R 49

9.2 Particulate Measurement and Sampling System

To be added later. For details see ISO 16183, US CFR Part 86, ECE R 49

10 Annexes

10.1 Essential Characteristics of the Engine and Information Concerning the Conduct of Tests

10.2 WHTC Engine Dynamometer Schedule

10.3 Reference Fuels

10.4 Determination of System Equivalence

10.5 Example of Calculation Procedure