ECE/TRANS/180/Add.4/Amend.1/Appendix 1

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GLOBAL REGISTRY

Created on 18 November 2004, pursuant to Article 6 of the
AGREEMENT CONCERNING THE ESTABLISHING OF GLOBAL TECHNICAL REGULATIONS FOR WHEELED VEHICLES, EQUIPMENT AND PARTS WHICH CAN BE FITTED AND/OR BE USED ON WHEELED VEHICLES
(ECE/TRANS/132 and Corr.1)
Done at Geneva on 25 June 1998

Addendum

Global technical regulation No. 4

TEST PROCEDURE FOR COMPRESSION-IGNITION (C.I.) ENGINES AND POSITIVE-IGNITION (P.I.) ENGINES FUELLED WITH NATURAL GAS (NG) OR LIQUEFIED PETROLEUM GAS (LPG) WITH REGARD TO THE EMISSION OF POLLUTANTS

Amendment 1

Appendix 1

Proposal and report pursuant to Article 6, paragraph 6.3.7. of the Agreement

- Proposal to amend global technical regulation No. 4 (TRANS/WP.29/AC.3/14).
- Report on the development of Amendment 1 to global technical regulation (gtr) No. 4: Test procedure for compression-ignition (C.I.) engines and positive-ignition (P.I.) engines fuelled with natural gas (NG) or liquefied petroleum gas (LPG) with regard to the emission of pollutants (ECE/TRANS/WP.29/2009/122).

UNITED NATIONS

PROPOSAL TO AMEND GLOBAL TECHNICAL REGULATION No. 4

I. OBJECTIVE OF THE PROPOSAL

1. The objective of this proposal is to introduce an amendment to the global technical regulation for heavy-duty vehicle emissions (gtr No. 4). This amendment is introduced with the aim of removing the options contained in document ECE/TRANS/180/Add.4 established in the Global Registry on 15 November 2006. The options refer to:

(a) Hot soak period
(b) Weighting factors for hot and cold phases
(c) Particulate sampling filter size and material
(d) Engine power definition

2. Regulations governing exhaust-emissions from all vehicles have been in use for many years but the methods of measurement vary. To ensure the maximum benefit to the environment as well as the efficient use of energy, it is desirable that as many countries as possible use the same high standards of emission control. In that context, this gtr is an important step forward.

3. Manufacturers of heavy-duty vehicles are already operating in a world market and it is economically inefficient for manufacturers to have to prepare different models in order to meet different emission regulations and methods of measuring CO_2/fuel consumption, which are, in principle, aimed at achieving the same objective. This gtr will enable vehicle manufacturers to develop new models in the most effective way.

II. DESCRIPTION OF THE GLOBAL TECHNICAL REGULATION

4. The regulation is based on 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. Based on real life data a model was developed for translating the vehicle cycle into an engine cycle. The general laboratory conditions for the emission test and the engine family concept have been brought up to date by expert committees in the International Organization for Standardization (ISO) and reflect the latest technologies.

5. 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 test procedure for measuring the emission performance of existing and future heavy-duty engines.

6. The next phase of work on this global technical regulation aims at eliminating the above-mentioned options in order to achieve a fully harmonised test procedure. AC.3 is therefore requested to agree that gtr No. 4 be amended and that the informal group established for the development of the gtr under the Working Party on Pollution and Energy (GRPE) continues its work on the amendment of the gtr.

7. While it is difficult to foresee a deadline, it is expected that phase 2 will be completed in two years.

REPORT ON THE DEVELOPMENT OF AMENDMENT 1 TO GLOBAL TECHNICAL REGULATION (GTR) No. 4: TEST PROCEDURE FOR COMPRESSION-IGNITION (C.I.) ENGINES AND POSITIVE-IGNITION (P.I.) ENGINES FUELLED WITH NATURAL GAS (NG) OR LIQUEFIED PETROLEUM GAS (LPG) WITH REGARD TO THE EMISSION OF POLLUTANTS

I. OBJECTIVE

8. The objective of the proposal is to amend the harmonized global technical regulation (gtr) No. 4 covering the Worldwide harmonized Heavy Duty Certification procedure (WHDC) which is the type-approval or certification procedure for heavy duty engines regarding its exhaust emissions. The basis will be the test procedure developed by the WHDC working group, subsidiary to GRPE.

9. Gtr No. 4 contains five options which can be selected by the Contracting Parties. This prevents a truly global application of the gtr. The United States of America, Canada and the European Community representatives although giving full support to the establishment of the gtr, expressed their concerns for the presence of options in the gtr. Therefore, the Executive Committee of the 1998 Agreement (WP.29/AC.3) requested, at its 140th session (14-17 November 2006), WHDC to resume its work in order to find a solution for the elimination of the options.

10. Furthermore, the representative of the United States of America added that the WHDC preamble specifically calls for review and possible revision of gtr No. 4 in the light of the completed procedures that result from the elaboration of the gtr on the exhaust emissions test protocol for non-road mobile machinery (NRMM).

11. In addition, India and China submitted some comments before the session of the World Forum (WP.29). However, those comments could not be discussed due to the short notice. The expert from India introduced the comment as informal document No. GRPE-53-08, proposing to amend in gtr No. 4 the definition of "high speed n_{hi}" in order to avoid difficulties in applying the test cycle for gas engines.

II. TIMETABLE AND EVALUATION OF OPTIONS

12. The following options needed to be considered:
    (a) engine power determination
    (b) reference fuel
    (c) hot soak period (5 or 20 minutes)
    (d) cold start weighting (10 per cent or 14 per cent)
    (e) Particulate Matter (PM) filter material (polytetrafluoroethylene (PTFE) coated glass fiber or PTFE membrane) and size (47 mm or 70 mm)

13. In order to find solutions, WHDC agreed on the following timetable:

Action	Date	Duration	Location	Purpose
20th WHDC meeting	06.06.07	0.5 days	Geneva	Agreement of principles
21st WHDC meeting	October 2007	2 days	San Francisco	Definition of work program
22nd WHDC meeting	January 2008	0.5 days	Geneva	Agreement of work program
23rd WHDC meeting	April 2008	2 days	Tokyo	Review of work progress
24th WHDC meeting	June 2008	0.5 days	Geneva	Review of work progress
25th WHDC meeting	October 2008	2 days	Beijing	Drafting of gtr
26th WHDC meeting	January 2009	0.5 days	Geneva	Submission of draft gtr
27th WHDC meeting	March 2009	3 days	Budapest	Finalization of draft gtr
28th WHDC meeting	June 2009	0.5 days	Geneva	Adoption by GRPE

Option 1: Engine power

14. No specific options are given in gtr No. 4, but the Contracting Parties can use their respective power standards/regulations. In principle, net power or gross power may be used:

(a) Net power (e.g. UNECE Regulation No. 85)
(b) Gross power (e.g. United States of America without specifying the method)

15. Brake specific emissions, as generally used for engine tests in the heavy duty testing environment, are expressed in grams per engine work delivered (g/kWh). This means that the emission level depends on the engine work (power) in the denominator. Since net power takes more engine auxiliaries into account, and is therefore lower than gross power, the emission level will be higher. However, the difference between gross and net power in the respective regulations is usually small.

Option 2: Reference fuel

16. No specific options are given in gtr No. 4, but the Contracting Parties can use their respective reference fuels. It is strongly recommended to use one of the three reference fuels listed in Annex 2:

(a) EU reference fuel
(b) USA reference fuel
(c) Japanese reference fuel

17. Fuel parameters have a significant influence on emissions. The most important source is fuel sulphur, but there are a couple of other fuel parameters that influence emissions and fuel consumption of an engine. Contrary to the sulphur influence, their magnitude is less predictable and unambiguous, but there is always a general trend that is valid for all engines. The most important of these parameters are cetane number, density, poly-aromatic content, total aromatics content and distillation characteristics. The following table shows the characteristics of the three recommended reference fuels and an average (artificial) reference fuel that complies with the specifications of the three reference fuels and that might be used for single engine testing, or by other Contracting Parties.

Fuel Specification	USA	EU	Japan	Compromise
Cetane number [-]	40 - 50	52 - 54	53 - 57	45 - 55
Density [kg/m³]	840 - 865	833 - 837	824 - 840	835 - 845
50 % BP [°C]	243 - 282	min 245	225 - 295	243 - 295
FBP [°C]	321 - 366	max 370	max 370	321 - 366
Viscosity [mm²/s]	2.0 – 3.2	2.3 - 3.3	3.0 - 4.5	2.0 - 4.0
Sulfur [ppm]	7 - 15	max 10	max 50 (10)	max 15
Aromatics [%]	min. 10	-	max 25	10 - 25
PAH [%]	-	2.0 - 6.0	max 5.0	2.0 - 6.0
Lubricity [µm]	-	max 400	-	-

Option 3: Hot soak period

18. The gtr contains two options for the hot soak period to be selected by the Contracting Parties:

(a) 5 ± 1 minutes

(b) 20 ± 1 minutes

19. The hot soak period is defined as the time between the end of the cold start cycle (engine shut-off) and the beginning of the hot start cycle (engine re-start). Whereas in the past the hot soak period did not have a significant influence on engines without aftertreatment devices, the behaviour of exhaust aftertreatment systems, increasingly used due to more stringent emissions limit values, might be influenced by the length of the hot soak period. Therefore, the United States of America did not agree to another soak time than the 20 minutes currently applied in their regulation. The European Union (EU) opted for the five minutes soak time in the amendment to UNECE Regulation No. 49 (ECE/TRANS/WP.29/2006/124) adopted by WP.29.

Option 4: Cold start weighting factor

20. The gtr contains two options for the cold start weighting factor to be selected by the Contracting Parties:

(a) 14 per cent

(b) 10 per cent

21. The United States (US) regulations require a cold start weighting factor of 14 per cent based on US in-use data. The EU opted for the 10 per cent weighting factor in the amendment to UNECE Regulation No. 49 (ECE/TRANS/WP.29/2006/124) adopted by WP.29. Proportion of cold start data from other Contracting Parties had not yet been reported. Due to the limited time of the WP.29 mandate, it was not possible to conduct a specific study on real world cold start portion of heavy duty vehicles. Therefore, WHDC members were asked to submit available data on cold start proportion under real world driving conditions for further analysis.

Option 5: PM filter material and size

22. The gtr contains two options for the filter material to be selected by the Contracting Parties:

(a) PTFE coated glass fiber filter
(b) PTFE membrane filter

and two options for the filter size to be selected by the Contracting Parties:

(c) 47 mm
(d) 70 mm

23. These options are especially critical, since different combinations are possible. For the time being, the United States of America and Japan have selected the combination PTFE membrane/47 mm in their regulations, while the EU opted for the combination PTFE coated glass fiber/70 mm in the amendment to UNECE Regulation No. 49 (document ECE/TRANS/WP.29/2006/124) adopted by WP.29. In general, the PTFE membrane filter is less sensitive to artefact formation on the filter surface, but more difficult to handle. The filter size itself is not considered having an influence on PM mass, but for the 47 mm filter a more accurate balance is commercially available.

Alignment with the gtr on NRMM

24. Parallel to the development of this gtr, the US Environmental Protection Agency (EPA) developed a new emissions measurement regulation covering all internal combustion engines. This regulation is referred to as Part 1065. Part 1065 includes neither limit values nor test cycles, but focuses solely on the emissions measurement procedures. On the other hand, the scope of a gtr is usually limited to a certain category of engines. Therefore, the general structure of this gtr is different from that of Part 1065.

25. The NRMM gtr will likely include new requirements from EPA Part 1065 that partly deviate from the requirements in gtr No. 4. For the sake of harmonization, it is desirable that the technical requirements for on-highway and non-road engines are largely identical. Alignment seems to be possible due to the parallel process of the amendment of this gtr and the further development of the gtr on NRMM. Since change of the structure of gtr No. 4 would require a high drafting workload without improving the technical requirements or the use of the gtr, it was agreed that the focus of the alignment should rather concentrate on the technical requirements than on the different structures.

III. ENGINE POWER

26. It was agreed to delete reference to power regulations from the gtr. Based on an evaluation by Technischer Überwachungs-Verein Nord (TÜV Nord) that test results with and without fan only show slight differences in brake specific emissions of between 1.2 and 3.5 per cent, it was further agreed to run emissions tests without fan, as with UNECE Regulation No. 96 for emissions from non-road engines.

27. Therefore, paragraph 6.3. was amended with a general guidance of how to install the

engine for the emissions test, and with provisions on how to treat engine auxiliaries and equipment for the emissions test. Specific equations were introduced for correction of engine power and torque with respect to auxiliaries and equipment that are not installed according to the general guidance. The list of auxiliaries and equipment to be considered for the emissions test was added as Annex 7 to the gtr.

IV. REFERENCE FUEL

28. Several test programs were conducted in the EU (Joint Research Centre - JRC), Japan (National Traffic Safety and Environment Laboratory - NTSEL) and the United States of America (Southwest Research Institute - SwRI) with engines of varying technologies:

(a) Euro V engine with selective catalytic reduction- SCR (JRC)
(b) US07 engine with diesel particulate filter - DPF (JRC)
(c) JP05 engine with NOx storage reduction - NSR/DPF (NTSEL)
(d) US07 engine retrofitted to US 10 NOx level with SCR/DPF (SwRI)

29. A US reference fuel and a EU reference fuel were supplied by the International Organization of Motor Vehicle Manufacturers (OICA) for all test programs. In addition, a EU reference fuel with 5 per cent biodiesel was investigated by JRC.

30. In general, NO_x and HC, emissions were higher with the US fuel compared to the EU fuel, whereas no significant fuel influence was observed for PM and carbon monoxide (CO). The soak times investigated (5, 10, 20 minutes) had no influence on the emissions. EU reference fuel with biodiesel was slightly lower for PM, CO and HC, but slightly higher on NO_x compared to the EU pure diesel reference fuel.

31. In general, the group concluded that some influence of fuels on emissions was observed, but it was small enough to allow only a single reference fuel in the gtr. However, the United States of America raised an objection to the use of an average reference fuel, since it does not cover the whole range of US reference fuel specifications. Therefore, GRPE at the fifty-eighth session finally decided that it was not possible to solve this issue and to leave gtr No. 4 unchanged with respect to the use of reference fuels.

V. HOT SOAK PERIOD AND COLD START WEIGHTING FACTOR

32. On these options, the United States of America expressed concern about backsliding on severity of US 2010 heavy duty emissions regulations, already in place. The United States of America proposed a validation test program with US 2010 and/or Euro VI engine technologies that appear unlikely to be completed in time for adoption by WP.29 in November 2009 due to timing and funding considerations. Therefore, WHDC sought advice of WP.29/AC.3 on the further procedure. WP.29/AC.3 agreed to exclude these options from the current mandate.

33. In a meeting between industry (Engine Manufacturers Association - EMA, European automobile manufacturer's association - ACEA) and EPA in November 2008, EPA agreed to separate soak time evaluation from general stringency evaluation, which would significantly reduce the testing burden compared to the original EPA proposal. This opened the door for further considering the options on soak time and cold start weighting factor.

34. Industry offered testing of US 2010 and Euro VI prototype engines, which could be supervised by EPA staff. The tests took place between March and July 2009 so that it was not possible for GRPE to take a final decision at the fifty-eighth session.

35. The amendment to the gtr therefore still includes the two options. Based on EPA review of the test results, it was suggested that the final decision on soak time and cold start weighting factor be taken by WP.29/AC.3 at the 149th session in November 2009.

VI. PM FILTER SPECIFICATION

36. A test program financed by OICA was conducted by TÜV Nord with the following engine technologies:

(a) Enhanced Environment-friendly vehicle (EEV) engine with SCR/DPF
(b) Euro V engine with SCR

37. The test results from both engines were very consistent. The average difference between constant volume sampler (CVS) and raw/partial flow dilution (PFD) was in the order of 1.3 per cent for NOx and 14.9 per cent for PM. The overall variability with the PTFE coated glass fiber filter was 20 per cent, with the best configuration being variant 2 (low dilution, high filter face velocity). No difference between 47 and 70 mm filter diameter was observed. The results with the PTFE membrane filter were slightly lower than PTFE coated glass fiber filter for the EEV engine, and slightly higher for the Euro V engine.

38. Therefore, WHDC agreed to resolve option 5 by deleting the 70 mm filter and by permitting both PTFE coated glass fiber and PTFE membrane filters. This is reflected in Amendment 1 to the gtr (ECE/TRANS/WP.29/2009/121).

VII. ALIGNMENT WITH NRMM GTR

39. As requested, alignment with the draft NRMM gtr with respect to the technical requirements has been largely achieved. This alignment also required considerable modifications to the structure of gtr No. 4, especially of section 7 (test procedures). Furthermore, minor corrections and corrigenda have been adopted at the fifty-eighth session of GRPE to be included into the final version of the gtr on WHDC for consideration and approval by WP.29/AC.3.

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