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Regulation No. 51 (Noise of M and N categories of vehicles) - Additional sound emission provisions

Proposal approach for Additional Sound Emission Provisions

Submitted by the Chairman of the Working Party on Noise*

The text reproduced below was prepared by the Chairman of the Working Party on Noise (GRB) in order to provide the experts of GRB with a possible approach for the incorporation of Additional Sound Emission Provisions (ASEP) into the text of Regulation No. 51.

* In accordance with the programme of work of the Inland Transport Committee for 2006–2010 (ECE/TRANS/166/Add.1, programme activity 02.4), the World Forum will develop, harmonize and update Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

I. Background Information

1. The GRB, in 2005, approved the adoption of the revised International Organization for Standardization (ISO) 362 test procedure (TRANS/WP.29/GRB/40) as the technical basis for future versions of Regulation No. 51 and Regulation No. 41 on vehicle noise. The ISO 362 test procedure discussed in GRB has been published by ISO as ISO 362-1:2007 for vehicles of categories M and N vehicles and as ISO 362-2 for vehicles of category L. The fundamental technical principle incorporated in procedures ISO 362-1 and ISO 362-2 was the specification of technology neutral vehicle operating conditions to estimate the actual 90^{th} percentile of in-use vehicle noise emission. The vehicle operating conditions have been chosen based on extensive in-use vehicle testing and subsequent statistical evaluations. To replicate the actual partial throttle operation of in-use vehicles, ISO specified a set of repeatable and reproducible test conditions that can be used to measure in-use partial throttle vehicle noise emission behaviour.

2. As a consequence of the change in technical testing methods, a number of contracting parties expressed concern regarding the change in vehicle engine speed (r.p.m.) used during the certification test. This change, generally but not in all cases, from a higher r.p.m. to a lower r.p.m., was a cause of preoccupation for the contracting parties. This preoccupation is due to the possibility that the vehicles could increase their actual level of noise emissions, due to the change in the technical test method. The specific nature of the concerns raised by contracting parties ranged from the desire to prohibit "cheating", a desire to check for 'nonlinear' behaviour, to a desire for an additional, independent, set of noise emission stringency tests for the approval of motor vehicles.

3. As a result of these concerns, GRB established (TRANS/WP.29/GRB/40) an informal group on Additional Sound Emission Provisions (ASEP) for Regulation No. 51, chaired by the expert from the Netherlands. The terms of reference for the group were established and approved by GRB (Annex 3 to TRANS/WP.29/GRB/40). This document intends to deal with the concerns raised in relation to the incorporation of ASEP into Regulation No.51.

4. At the September 2009 session of GRB, the Chairman of the informal group reported to GRB that a consensus recommendation to GRB on Regulation No. 51 ASEP was not possible. The Chairman presented a test and evaluation proposal that had been discussed by the informal group and was supported by some contracting parties, but without corresponding stringency values. Separately, the Netherlands presented a second ASEP proposal, which used elements of the proposal discussed in the informal group, but differed in other aspects. This proposal contained stringency values. This situation left GRB without a clear path forward. At the February 2010 meeting, while there was no further progress on a single consensus proposal, there was, however, an strong opinion expressed by contracting parties and accredited NGOs that a prompt resolution of this issue was necessary. Accordingly, the GRB Chairman offered to prepare a paper on the issue for discussion at the September 2009 session of GRB, with the intention of reviewing what progress had been made, what issues were remaining, and to seek for some way to bring the matter to a prompt resolution, as expressed by GRB.

II. What is a "vehicle of concern"?

5. Prior to any discussion regarding ASEP, some common understanding and definition of the type of vehicle behaviour that is deemed objectionable must be established. If this were not to take place, all further discussion of ASEP testing methods, operating conditions, analysis procedures, and stringency values will create conflicting

scenarios where the objectives of each method, condition, procedure, and value cannot be expected to be aligned. In 2005, GRB established the following (see TRANS/WP.29/GRB/2005/2) under point 6.2.3, reproduced below.

"6.2.3. Additional sound emission provisions

The additional sound emission provisions apply to vehicles of categories M_1 and N_1 only.

They are preventive requirements intended to also cover the driving performance of the vehicle in real traffic, which can be environmentally relevant in terms of sound emissions and which differs from those during type approval testing, described in Annex 3, of Regulation No 51.

6.2.3.1. The vehicle manufacturer shall not intentionally alter, adjust, or introduce any mechanical, electrical, thermal, or other type of device or procedure solely for the purpose of fulfilling the sound emission requirements specified in this Regulation and as determined by the test procedure of Annex 3, but which will not be operational during typical on-road operation. These measures are commonly referred to as "cycle detection".

6.2.3.2. Any control device, function, system or measure that could affect the sound output may be installed on a vehicle provided that:

(a) it is activated only for such purposes as engine protection, cold starting or warming up, or

(b) it is activated only for such purposes as operational security or safety and limp home strategies, or

(c) it is required to fulfil this and/or other Regulations.

6.2.3.3. The sound emission of the vehicle under normal driving conditions different from the conditions of the type approval test in Annex 3 shall not differ considerably from what can be expected from the type approval test result for this specific vehicle with regard to technical practicability. This is fulfilled if the requirements of Annex 10 are met."

6. Each of these paragraphs was written to address the concerns of the contracting parties and accredited NGOs. There are a number of major points which can be identified, the first of which are environmentally relevant driving conditions which differ from the type approval test. As the $L_{\_Urban}$ value defines the 90^{th} percentile of expected noise emission, ASEP concerns itself with the remaining 10 per cent of expected noise emission. Given that the main way for a vehicle to exceed the $L_{\_Urban}$ value is to accelerate, the ASEP conditions are transient in nature, as they are not expected to cover steady state conditions. This clearly established that ASEP shall, in some manner, evaluate vehicle performance in conditions other than the operating conditions specified in determining $L_{\_Urban}$. As discussed later in this proposal approach, the ASEP informal group was able to agree on a definition of vehicle operating conditions to achieve this point.

7. The following paragraphs describe various conditions where a vehicle's level of noise emission could be a matter of concern. Paragraph 6.2.3.1 clearly specifies that manufactures shall undertake no measures that would undermine either the mandate or the intention of the noise emission regulations. The reported $L_{\_Urban}$ value must be recognized by all parties as a truthful representation of noise emission for that vehicle. The concept of "cycle detection" is well understood in vehicle emission regulations. For the purpose of Regulation No. 51, it is understood to be any behaviour of a vehicle that causes such an unexpected increase in noise emission that an untrained bystander would be likely to ask: "What happened?". As a matter of judgment, a noise emission increase of 10 dB over a very short increment of engine speed (r.p.m.) or vehicle speed (km/hr) can be understood to be of concern. "Very short" can certainly be a matter of opinion, but this can be reasonably expected to include an increase of less than 100 r.p.m. and less than 2 km/h. The ASEP test should have a high probability of detecting such behaviour.

8. Paragraph 6.2.3.2 addresses the concern relating to protecting against inadvertent and unintended misapplication of ASEP that would cause a vehicle to be rejected when the behaviour in question is necessary for some reason. As it is impossible to anticipate every possible technical development, this paragraph was included to provide guidance to approval authorities and manufacturers on what kind of vehicle conditions are not a matter of concern.

9. These three above-mentioned paragraphs, while open to some interpretation, are relatively straightforward and have not been the main focus of the ASEP informal group discussions. However, paragraph 6.2.3.3 uses wording that is are open to interpretation. The most significant of these is: "differ considerably from what can be expected from the type approval test result." That this paragraph is actually interpreted differently by different parties is demonstrated by the criteria given for the determination of the term "vehicle of concern", which are given below:

(a) Evidence of test beating and/or cycle detection.

(b) Unexpected vehicle noise behaviour based on the individual vehicle's technical capability.

(c) Noise emission greater than 85 dB (A) anywhere in the ASEP control range.

(d) Non-compliance with the limits of the 02 series of amendments to Regulation No. 51.

(e) Noise emission higher than absolute dB/r.p.m. slope, with different approaches for determining a reference point.

(f) Allowance for, or prevention of, vehicles with noise emission below type approval limit values to increase noise emissions in the ASEP control range.

(g) Evaluation of ASEP noise emission using the technical procedures of the base compliance test ($L_{\_Urban}$).

10. With these various alternative criteria of what constitutes a vehicle of concern, it is understandable that the ASEP informal group has experienced difficulties in reaching a consensus view on the necessary measures for carrying out the wishes of GRB as expressed in the main body of the text and in the terms of reference for the ASEP informal group. As the ASEP informal group has not defined the term "vehicle of concern", the different impressions, interpretations, and opinions of each of the participants are expressed in various proposals for analysis methods and limit schemes. The differences in position essentially come down to a difference in how the purpose of ASEP is understood. Is ASEP a means to ensure no cheating takes place (in the sense of manufacturers taking deliberate measures to evade the intended purpose of the regulation) while not imposing design or

technology limitations on the vehicle? Or rather, is ASEP understood to be an additional regulatory stringency measure on vehicle design and technology to provide necessary environmental benefit? The answers to these questions are fundamental to determine the course of action to take with regard to ASEP.

11. What has been agreed upon by the ASEP informal group are the operating conditions relating to ASEP. These criteria are (see informal document No. GRB-50-10):

(a) Vehicle speed range.

(b) Vehicle acceleration.

(c) Vehicle engine speed (r.p.m.).

12. These criteria define an operating envelope of vehicle performance that is subject to ASEP testing and limits.

III. Possible approaches for ASEP

13. Informal group status

The proposal developed through the ASEP informal group (IG) pertains to the expected noise emission of the vehicle through an estimation of the vehicle's dB/r.p.m. behaviour. To account for uncertainty, there are additional terms to determine the offset from a reference point and dB/r.p.m. Terms are also provided to limit the dB/r.p.m. slope. The method is based on the actual performance demonstrated during the base type approval test. As each of the testing terms can be chosen and applied in any combination, there are a range of possible stringency conditions possible under this method.

14. Netherlands proposal

The proposal elaborated by the Netherlands establishes a fixed "do not exceed" value at an given engine speed (r.p.m.). In addition, it establishes a boundary between this point and the type approval point to assess noise emission behaviour. As with the informal group proposal, there is a term to account for uncertainty. There is also a "bonus" for vehicles with type approval values less than the limit.

15. Kraftfahrt-Bundesamt (KBA)/ Modified KBA

The proposal from the German KBA was to provide an analysis method using the ASEP data to estimate the 02 series of amendments to the Regulation No. 51. compliance point.

This is an additional requirement to the informal group status (see point 13 above).

16. Do Not Exceed

This proposal would establish a fixed "do not exceed" noise emission value for all vehicle operating conditions.

17. $L_{\_Urban}$

While not specifically presented as a proposal, this scheme would assess any Wide Open Throttle (WOT) vehicle result within the ASEP control boundary by using the one-gear $L_{\_Urban}$ calculation.

IV. Consequences of possible approaches

18. Informal group status

This proposal is structured to detect nonlinear behaviour in a vehicle's noise emission, specifically to look at nonlinear (with respect to engine r.p.m.) increases in noise emission that cannot be explained by the underlying physics of internal combustion engine power output. The intent of this proposal is to detect 'cycle beating' schemes, but not to provide independent stringency on a vehicle's noise emission. The ability to select the parameters of the method allow for stringency to be vary according to the selection. The selection of parameters consistent with the intent of this proposal would ensure that all vehicles which comply with the type approval limits, and have no unexpected behaviour, would comply with ASEP limits. This proposal does not provide a specific 'do not exceed' value, but noise emission in the ASEP control range is limited as a function of the allowed engine r.p.m. range within the vehicle performance envelope. Due to the fundamental use of dB/r.p.m. as the basis for the assessment of vehicle noise emission, this proposal is unable to be used for electric and future advanced propulsion technology vehicles.

19. Netherlands proposal

This proposal's primary intention is to ensure all vehicles do not produce more than a specified noise emission, independent of the technology used by the vehicle and independent of the vehicle's type approval value. Adoption of this proposal would bring about an ASEP method that would provide independent design and technology stringency on vehicle noise emission. Due to some aspects of the 'do not exceed' concept, and the extra allowance in noise emission proposed for silent cars, this proposal will not be able to detect unexpected nonlinear behaviour for some vehicles. As this proposal retains some aspect of dB/r.p.m. limits from the IG status, this proposal will also be unable to be used for the assessment of electric and future advanced technology vehicles, although not to the same extent as the IG status.

20. KBA/Modified KBA

This proposal intends to provide assurance to Governments and regulatory authorities that no matter what the specific technical methods of any new Regulation No. 51 type approval or off-cycle test, a vehicle noise emission would in no case be higher than allowed under the 02 series of amendments to Regulation No. 51. The original KBA proposal assumed the existence of ASEP test data as given in the IG ASEP status. However, the KBA proposal could be structured in such a way as to be independent of any ASEP method by requiring a track test to be run at the specified KBA condition.

21. Do Not Exceed

While no contracting party has specifically proposed this concept, it has been discussed and is incorporated in a certain fashion in the proposal from the Netherlands. This concept simply sets a noise target that a vehicle shall not exceed. This concept is not interested in the behaviour of the noise emission as a function of engine r.p.m., vehicle speed, or any other parameter. An implication of this approach is that the concept of back to back testing for replacement exhaust systems cannot be used; it is only the absolute level of noise that is of interest. The consequence of this is replacement systems can be approved that have noise emission exceeding those of the original vehicle system. As this concept does not use engine r.p.m. or other vehicle design parameters, it is suitable for all vehicle technologies.

22. $L_{\_Urban}$

This concept was presented by the Chairman of ISO Working Group 42 (WG42) as an analysis tool to assess the relative stringency of ASEP proposals compared to the type approval result. This concept provides an answer to the "As expected" question by using the same procedure as the type approval result. This procedure expects the noise emission of the vehicle to be proportional to the power output of the engine, using the achieved acceleration as a proxy for the power output. This analysis will identify nonlinear noise behaviour either due to changes in noise output or due to failure to produce power (acceleration) during the test. Since the test is based on the same performance based and design-independent criteria as the type approval test, it can be used for all vehicle propulsion technologies.

V. Proposed approach

23. Each of the concerns expressed by contracting parties has merit; it is necessary to balance the goals to achieve a positive result for the environment at a reasonable cost to society. As off-cycle noise cannot be assessed within the framework of cost-benefit used for the base type approval value; (meaning the noise emission under off-cycle will have no effect on L_{eq} values, and therefore no calculated benefit for society), decisions must be made on a pragmatic basis. For these reasons, a package of measures has been proposed to address the concerns expressed in GRB, while providing a framework for the implementation of ASEP coincident with the amendments to Regulation No. 51.

24. The package of measures seeks to achieve the following goals:

(a) All vehicles are subject to ASEP (no exceptions for vehicle technologies).

(b) Noise emission shall be guaranteed to be at or below noise emission stipulated under the current Regulation.

(c) Cycle detection schemes shall have a high probability of being detected.

(d) The base type approval test shall be the technical stringency measure for the vehicle.

(e) Regulators shall have a reasonable assurance that the type approval test covers real world operating conditions.

(f) ASEP shall provide a basis to perform back to back testing for replacement exhaust systems.

25. The measures proposed are to be treated as a package. They are proposed to provide an overall achievable and necessary set of measures to sufficiently address all concerns. The specific content of the package is as follows:

(a) Use of the operating condition envelope agreed by the ASEP informal group: r.p.m. boundary as function of r.p.m., 4.0 m/s^2 acceleration boundary, and vehicle speed between 30 and 80 km/hr.

(b) Use of margin or limit:

(i) Use of the informal group status test points and analysis methods; Parameters chosen as 5 dB/1000 r.p.m., margin of 2 dB, and edging of 1 dB;

or

(ii) Use 1-gear $L_{\_Urban}$ method as described by ISO with a limit of 3 dB (A).

(c) Establishment of an independent control point per KBA proposal to ensure that noise emission levels remain as good as under the current Regulation.

(d) Modify the base type approval test to change the acceleration boundary from 2.0 m/s^2 to 3.0 m/s^2.

26. Each of these measures addresses the expressed concerns as follows: The first item sets the boundary on environmentally relevant operating conditions. It also takes into account practical test considerations of safety test operations. The second item(s) provides the means to assess the vehicle's noise behaviour consistent with what can be reasonably expected, with a high probability of detecting any cycle beating scheme. The third item is to provide assurance to Governments and society in general that the change in technical test methods does not allow for any means of allowing increased noise emission.

27. The fourth, and final item, is a change to a type approval parameter, in order to provide assurance to Governments and society that the test will be carried out in operating conditions deemed to be more representative of vehicle noise by Governments; this is for the purpose of ensuring confidence in the test values given by the type approval test.

V. Summary

28. The current situation and state of development of Regulation No. 51 ASEP has been presented. A review of the concerns expressed, the approaches discussed, and evaluation of the expected consequences of each proposed approach has been provided in non-technical terms. A proposal to address the concerns expressed has been provided that reaches, in the opinion the Chairman of GRB, the goals set forth by GRB for the purpose of ASEP in a sufficient manner to provide a basis for agreement by GRB and subsequent adoption by WP.29. As with any compromise proposal, no one will be completely satisfied, but each expressed policy goal of GRB can be shown to have been satisfied.