New EU Regulation on the sound level of motor vehicles

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ABSTRACT

Before the end of 2013, the responsible institutions of the European Union will probably decide on a proposal for a new "Regulation on the sound level of motor vehicles." It will specify a new type approval test method for noise emission and will give revised limit values for the permissible noise emission per vehicle (sub-)category. The new regulation may be seen as a final stage of a long series of developments towards a more representative way of testing, but at the same time it should be a starting phase of regular reductions of limit values to achieve a substantial reduction of traffic noise impact and improvement of urban environmental conditions. This article describes the historical development of noise emission test methods, the shortcomings of the current test method and the expected improvements resulting from the new test method. The predicted environmental and health effects of the new Regulation are presented and an outlook to future developments concerning vehicle noise emission test methods is given.

1. INTRODUCTION

On December 6, 2011 the European Commission (EC) issued a Proposal for a Regulation of the European Parliament and of the Council on the sound level of motor vehicles [1]. After acceptation, this regulation will replace the Directive 70/157/EEC [2] that has been the basis for legislation on vehicle noise emission in the EU member states since 1970. The new regulation proposes the introduction of a fundamentally revised measurement method for the noise emission of road vehicles and a revised set of limit values that regulates the permitted noise emission of road vehicles of all categories and subcategories. Since the publication of the proposal, the European Parliament (EP) has studied, discussed and amended the proposed requirements. On February 6, 2013, the EP has voted on the amendments in first reading [3]. In the process on decision making after that step, it was the turn of the Council of the EU (the Ministers of the Member States) to consider the proposal and to amend or accept the earlier positions of the EC and the EP. In November 2013 the Committee of Permanent Representatives of the EU member States endorsed a provisional agreement that was reached between the Lithuanian presidency of the Council and representatives of the EU Parliament [30], [31]. This paved the way for the formal adoption of the new regulation by a vote of the EU Parliament.

The basic reason for the revision is that during the long period of existence of vehicle noise regulations, no reduction of the average noise emission in traffic of individual passenger cars has been achieved, in spite of the fact that in this period the type approval limit values for noise emission have been lowered by 8 dB(A) (see Figure 1; ref [13]). For trucks the situation is somewhat more favorable: an average reduction of 4 - 5 dB(A) in traffic has been obtained, while the reduction of the limit values was 11 - 12 dB(A). In section 2.3 these facts will be discussed in more detail.

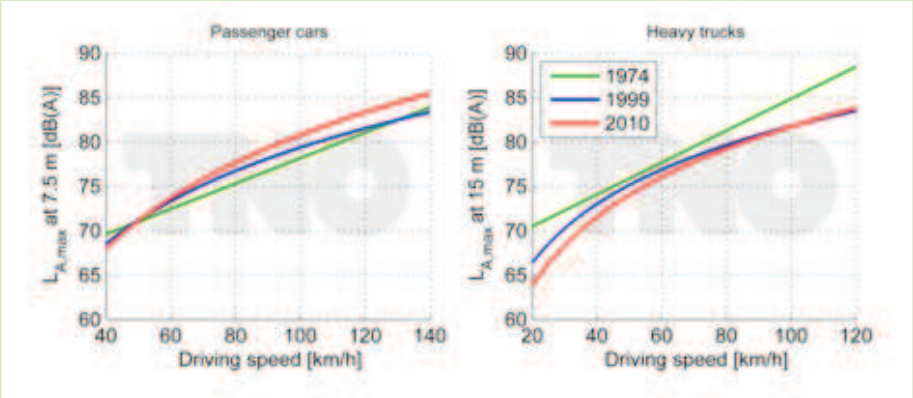


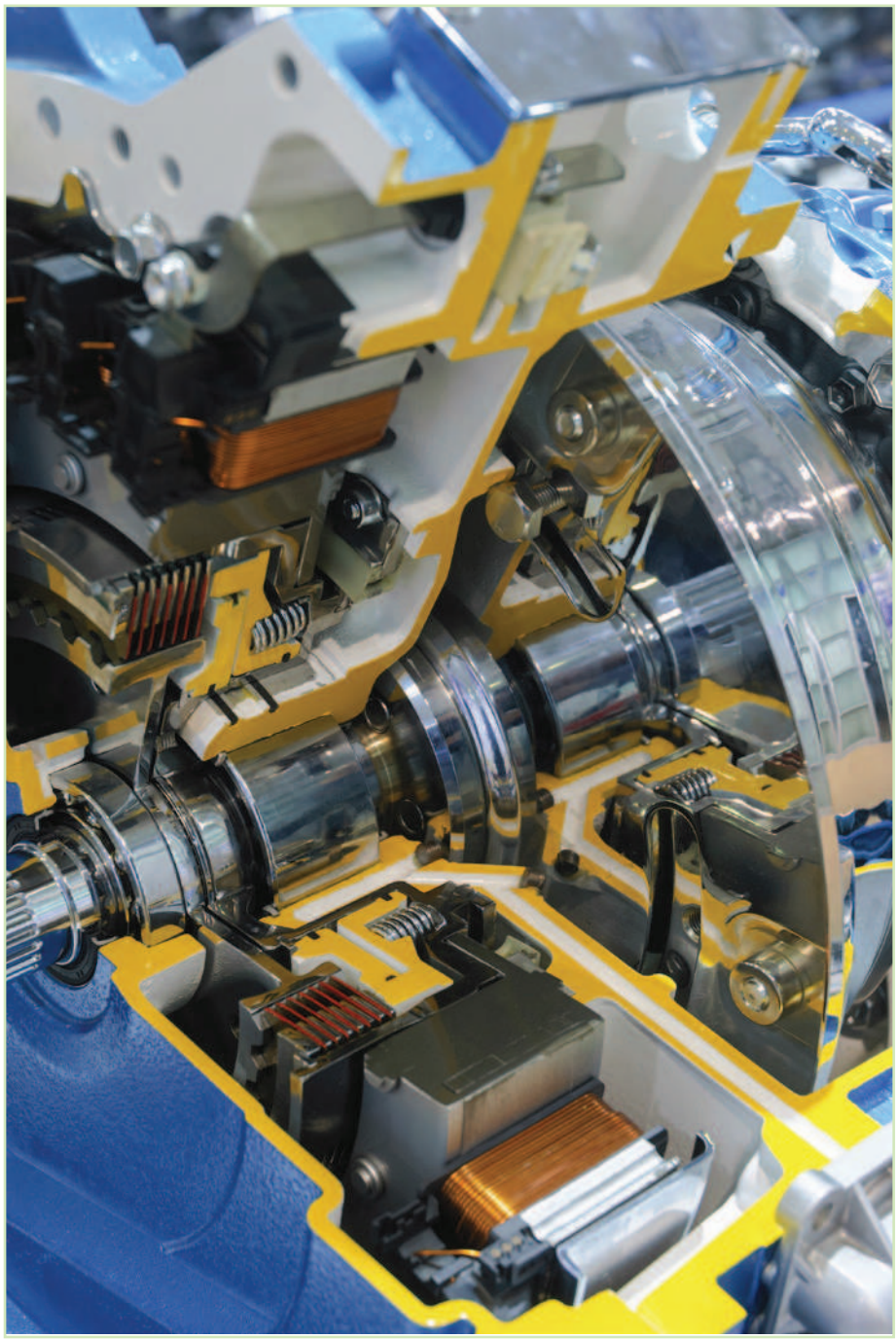
Figure 1 - Comparison of in-traffic noise emission of passenger cars and (heavy) trucks in The Netherlands in 1974, 1999 and 2010 [13].

The duration of the decision making process may seem long, but it was actually rather short compared to the period of preparation of the revision that preceded the proposal of December 6, 2011. In this article the history of the European vehicle legislation with respect to noise emission will be discussed and explained, and interpreted from an acoustical point of view.

2. HISTORY OF THE VEHICLE NOISE EMISSION REGULATIONS

2.1 Intentions of the original Directive

The original motivation in the years before 1970 to issue a Council Directive "on the approximation of laws of the Member States relating to the permissible sound level and exhaust system of motor vehicles" was not based on considerations of environmental management, but mainly on the need to harmonize the legislation in the EU Member States. In the preamble of the Directive, it is clearly stated that it was primarily driven by economic considerations aimed at removing trade barriers. It specified seven vehicle categories and the prescribed test method was as simple as possible. This method was copied from ISO Recommendation 362, dating from 1961[4a]. This recommendation was replaced by an ISO standard in 1981 [4b]. As stated in the scope of this standard, "the method was designed to meet the requirements of simplicity as far as they were consistent with reproducibility of results and realism in the operating conditions of the vehicle." The specifications were intended "to reproduce the noise levels in urban traffic flow of irregular character which requires the use of intermediate gears with full utilization of the engine power available." These statements express clearly that the aim of the test was to measure the maximum noise levels that could be produced by the vehicle drive line in urban traffic conditions.



The basic test conditions were full throttle acceleration at approximately 50 km/h in second gear (for a two- three- or four-speed gear box) or in third gear (for a gear box with more than four gears). In this way of testing the contribution of tire/road noise to the test results was of minor importance. The limits values specified were aimed at regulating the maximum noise levels, and not the average noise emission in traffic. Therefore the first set of limit values did not have much impact

on the actual noise emission of the road vehicles in practice, and served primarily as a ceiling for excessively high noise levels.

2.2 Modifications and revisions to the Directive

After the introduction in 1970 the principles of the Directive and the details of the test method were changed repeatedly. The most relevant modifications, amendments and notes are:

- Dir. 81/334/EEC that came into force between 01/01/1982 and 01/10/1985 required that light vehicles with more than four gears were to be measured in second and third gear, from which the results were averaged to a single overall level [5].
- Dir. 84/372/EEC that came into force between 01/10/1984 and 01/10/1986: Powerful cars with more than 140 kW, > 75kW/t and a minimal achieved speed of 61 km/h over the test section by the microphone should only be measured in third gear. The procedure for vehicles with automatic gearboxes was also adapted [6].
- Dir. 92/97/EEC that came into force between 01/07/1993 and 01/10/1996 [7] specified the test track according to the ISO 10844 standard [8]. Previously, all types of road surfaces were allowed, including absorbing ones.
- Dir. 96/20/EC that came into force between 01/10/1996 and 01/01/1997 allowed the use of test tires with a minimal tread depth of 1,6 mm [9].
- Dir. 99/101/EC that came into force between 01/04/2000 and 01/10/2000, concerning the use of replacement silencers [10].
- An extra 1 dB(A) is allowed to compensate for measurement inaccuracy. Vehicles with off-road capabilities, vehicles with a direct injection Diesel engine, and the 'powerful cars' (see second bullet above) have another extra 1 dB(A) allowance.

The specified limit values changed four times as indicated in Table 1.

2.3 Investigations into the effect of type approval testing

Although the requirements had been introduced for the purpose of harmonization of the vehicle regulations in the different EU Member States, sometime later environmental considerations also began to play a role and several member states saw the vehicle noise Directive as a tool for controlling and reducing the noise emission of road vehicles. The expectations were that by lowering the limit values for the type approval test, the in-traffic noise emission of road vehicles would also be reduced.

In the period from 1985 until 2000 in several Member States, e.g. Germany and The Netherlands, measurement campaigns were organized to compare the noise emission levels of individual vehicles of the newest generations with the values that were known from the past [11], [12]. Soon it was observed that the noise emission of vehicles in traffic did not decrease at the same rate as the reduction of the limit values. Research began to investigate the reasons for this discrepancy. Results of type approval tests, according to different test methods, were compared with results of representative urban drives [14], [16], [17].

The results of these studies showed that the correlation between the test results of ISO/R 362:1961 or ISO 362:1981 and actual noise emission measurements in traffic were rather poor. A much better correlation (up to r = 0,89) was found between the results of testing according to ISO 7188:1985 [15] and actual traffic noise emissions. This alternative ISO standard specified a test method based on a combination of full throttle acceleration and constant speed, both at 50 km/h.

In the 1990s, the International Institute of Noise Control Engineers (I-INCE) formed an international working party to carry out a comprehensive study into the effect of regulations on the noise emissions of road vehicles. The final report of this

EU Directive		70/157/EEC	77/212/EEC	84/424/EEC	92/97/EEC
Year of enforcement		1970	1977 - 1982	1985 – 1990	1993 – 1996
Vehicle category		**Limit value in dB(A)**			
Passenger car		82	80	77	74
Delivery van and minibus	Max mass ≤ 2 tons	84	81	78	76
	Max. mass >2 tons ; ≤ 3,5 tons	84	81	79	77
Buses > 3,5 tons	Rated power < 150 kW	89	82	80	78
	Rated power ≥ 150 kW	91	85	83	80
Trucks > 3,5 tons	Rated power < 75 kW	89	86	81	77
	Rated power ≥ 75 kW; < 150 kW	89	86	83	78
	Rated power ≥ 150 kW	91	88	84	80

Table 1 - Historical overview of the development of the type approval noise limit values for new road vehicles since the official introduction in 1970.

working party [18] appeared in 2001 and confirmed most of the earlier conclusions and summed up the reasons for the limited effectiveness of the regulations. The most important of these are the lack of relevance and representativeness of the test method, as well as the fact that lowering of the limit values coincided several times with a modification of the test conditions. The resulted in a lowering of the test results, thereby neutralizing the effect of the stricter limit values. The lack of representativeness leads to a significant underestimation of tire/road noise in the test results, while tire/road noise is the dominant type of noise for the greater part of the urban traffic conditions. It means that tire/road noise is only to a very small extent influenced by the type approval limit values.

2.4 Developments towards a more representative test method

In the early 1990s the facts and conclusions discussed above had become known. ISO Technical Committee 43 'Acoustics,' had previously been responsible for the development of ISO 362 and ISO 7188 and decided to install a new Working Group 42 that should review the existing test methods and develop a method that could be the basis for a more relevant and representative way of testing. This WG started its work in 1993 and is actively involved in the development of test methods used today.

After some smaller revisions of ISO 362 in 1994 and 1998, WG 42 carried out a fundamental revision of ISO 362 that was published in 2007 [4c].

In line with the findings from the 1980s [14], [16] in this new revision the principle of ISO 7188 was chosen as the basis for a new test method for light vehicles (passenger cars and light vans). The constant speed part of that test method could be representative for constant speed free flowing traffic in urban environments, but the full throttle acceleration part was not very representative for normal acceleration at urban intersections. After extensive study and testing, the ACEA (European Automobile Manufacturers' Association) submitted a proposal that combined the constant speed testing with a vehicle specific reference acceleration that was to be derived from the power-to-mass ratio of the vehicle under test. The final test result is a weighted average between the partial test results of the acceleration test and the constant speed test. In most cases both partial tests will be executed in two different gears and the partial results are averaged.

By using a mix of acceleration test results and cruise-by test results, the final result is supposed to be representative for the noise emission during partial power acceleration at approximately 50 km/h in intermediate gears. According to investigations of urban traffic patterns, a speed of approximately 50 km/h may be considered as the most frequently occurring [19], while partial power acceleration on urban main streets is the condition that contributes most to traffic noise disturbance and annoyance [20]. Testing at partial power conditions is very difficult to execute and reproduce. Therefore the rather complex test procedure consisting of two acceleration tests and two cruise-by tests was developed in order to realize a representative as well as reproducible test procedure.

For heavy vehicles the modifications of the test procedure in the revised standard ISO 362 were far less radical than for light vehicles. The principle of the test continued to be testing at full throttle conditions in various intermediate gears. The most important change was that heavy vehicles would be tested in partly laden condition instead of unladen condition. This change was intended to prevent the generation of abnormal tire/road noise that could occur by slip of the driven wheels under high torque without sufficient loading on the drive axle.

2.5 Monitoring period for the new test method

After publication of this new test method by ISO [4c] the method was submitted to the GRB group (Groupe Rapporteur Bruit = Working Party on Noise) of the UNECE (United Nations Economic Commission for Europe). This group of experts conducts research and analysis to develop noise requirements for vehicles and prepares regulatory proposals on noise to WP.29. WP.29 is a permanent working party in the institutional framework of the United Nations that works as a global forum for open discussions on motor vehicle regulations. Any member country of the United Nations and any regional economic integration organization, set up by country members of the United Nations, may participate fully in the activities of the World Forum and may become a contracting party to the Agreements on vehicles administered by the World Forum. Governmental and non-governmental organizations (NGOs) may also participate in a consultative capacity in WP.29 or in its subsidiary working groups. The European Commission as well as the EU member states participate in the GRB and employ the GRB regulations as a basis for EU Directives and regulations.

The UN-ECE GRB published the new test method in 2007, based on the revised ISO 362 standard, with the purpose of monitoring the application of this new method in parallel with the existing test method and to evaluate the qualities of the new method. During a period of three years the new method has been used for monitoring purposes. This monitoring period under UN-ECE Regulation No 51 [21] lasted from 1 July 2007 until 1 July 2009. In addition, the EC initiated a monitoring period under Directive 2007/34/EC [22] that started on 6 July 2008 and expired on 6 July 2010. During

the monitoring periods, the results of the old and of the new test method for all tested vehicles were submitted to the European Commission. By this procedure, a database of parallel test results was collected that offered a good opportunity to investigate the qualities of the new method and to quantify the differences between the results of the two methods.

2.6 VENOLIVA study and report

At the request of the European Commission, TNO has executed a study into the differences between the old test method A and the proposed new test method B.

2.6.1 Goal of the study and approach

The goal of the study was to "assess the available noise data in relation to the draft new test protocol and to provide possible new limit values for each category of vehicles, as well as for the derogations currently granted for certain types of vehicles." The acronym of the study was VENOLIVA (Vehicle Noise Limit Values) [23].

The research questions that had to be answered by the study were:

a. What will be the effectiveness and the practicability of the new method B in comparison to the old method A?

b. How should the limit values for noise emission of the different vehicle categories be changed for each of five possible Policy Options:

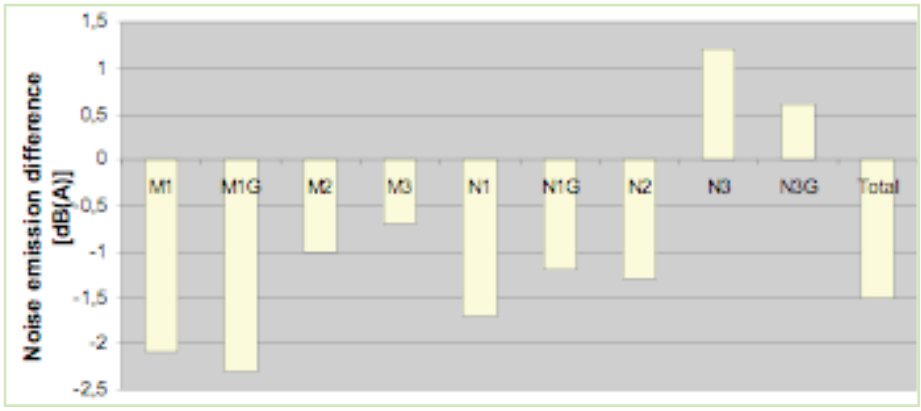


Figure 3. Average difference between the test results of methods B and A per vehicle category.

- Policy Option 1 – No change;
- Policy Option 2 – New method – old limit values;
- Policy Option 3 – New method – new limit values equivalent to old ones;
- Policy Option 4 – New method – new limit values with noise reduction potential;
- Policy Option 5 – New method – new limit values with enhanced noise reduction potential in two step approach.

c. How should the allowances that are currently in force for special vehicles (high-powered cars, off-road vehicles and vehicles with a direct-injection Diesel engine) be treated under a new system of limit values?

d. What will be the environmental, social and economic impact of each of the five Policy Options and of the revision of the system of allowances?

e. If the new test method is expected to cause problems for the efficiency of the noise measurements, how can the test method be modified in order to prevent these problems?

f. If the new test method cannot guarantee that the noise emission during operating conditions, other than the test conditions, does not exceed the test results significantly, what type of off-cycle provisions can be introduced to achieve this goal?

The most substantial part of the study was the statistical and acoustical analysis of the measurement data of both test methods that had been submitted to the European Commission. In addition, many other data sources and literature concerning noise emission of vehicles were studied and a small enquiry among type approval authorities was held and the environmental, social, and economic impacts of the five Policy Options were investigated.

One of the most important results of the study is the average difference between the test results obtained during the monitoring period with the old method A and the new method B for the different vehicle categories. This result is presented in Figure 3 and Table 3.

2.6.2 Recommendations for revised limit values

Based on the differences between the average results of the methods A and B, the correlations between these results and the distributions of the results of method B, proposals were drafted for the specification of limit values under the five Policy Options. For each of these Options and the corresponding limit values, the predicted change of the noise emission of the different vehicle categories in normal traffic was assessed. From these emission changes, the changes in noise impact and in the prevalence of noise annoyance and sleep disturbance in the population were estimated.

In the elaboration of the limit values under the five Policy Options, account was taken of the influence of the recent EU Regulation addressing the tire rolling noise [24].

This regulation is being implemented in three phases from 1 November 2012 until 1 November 2016. The stricter rolling noise limit values in this regulation will lead to a reduction of rolling noise in traffic as well as during vehicle type approval tests. This means that the results of the vehicle noise tests will decrease in the coming years, even without any change of the limit values for vehicle noise. In the VENOLIVA study, an estimated assessment was made of the average noise reductions for passenger cars and other light vehicles [23], [25] that will result from the stricter tire noise limit values.

After evaluation of the results of the impact analysis (research question d.), it was recommended to implement the limit values according to Option 5. In this option, the consequences of the transition to the new test method B were combined with the aim of achieving a significant reduction of vehicle noise emission in traffic in a two-step scheme. In the first step of this option, the limit values for passenger cars would be lowered by 2 dB to compensate for the difference between the test methods and with 2 dB to achieve a defacto noise emission reduction. In the second step, again 2 dB reduction would be introduced. The total change would be -6 dB in a numerical sense or -4 dB effectively. For heavy trucks the first step would combine a raise of 1 dB for test method compensation and a lowering of 1 dB for noise emission reduction. The second step would introduce a reduction of 2 dB, giving a total change of - 2 dB numerically or - 3 dB effectively. Similarly for other categories, effective reductions of 4 dB were recommended for light vehicles and buses and 3 dB for medium and heavy trucks.

3. EC PROPOSAL FOR A NEW REGULATION

The European Commission largely adopted the recommendations of the VENOLIVA report and issued a Proposal for a Regulation of the European Parliament and of the Council on the sound level of motor vehicles [1] on December 6, 2011. The proposal for the new regulation proposes to replace the old test method by the new one, with some small changes compared to the test method published by UNECE in 2007 [21]. The proposed revised set of limit values was fully in line with the VENOLIVA recommendations. In connection to the new test method, the concept of Additional Sound Emission Provisions (ASEP) was also introduced. A consequence of the operating conditions of method B will be a shift from pure powertrain noise emission in the test to a mixture of both powertrain and rolling noise. Moreover, in most cases the test is executed at relatively low engine speeds, which results in lower powertrain/exhaust noise than in the old method. This introduces the risk of unregulated noise emissions at high engine speeds, when the noise emission at high engine speeds deviates strongly from the noise emitted at low engine speeds. This may be the case for powerful sports cars that have a high acceleration potential. For these cases the ASEP requirements try to control the noise at operating conditions that are not covered by the method B test. In support of these requirements a measuring method to evaluate compliance with the additional sound emission provisions was also published as an Annex to the EC Proposal.

Since the publication of the proposal, the European Parliament (EP) has studied, discussed and amended the proposed requirements [3]. The amendments entailed a significant weakening of the noise reduction potential of the proposed regulation. The next step in the decision making process was the consideration of the EC proposal by the Council of the EU (the Ministers of the Member States) that should result in the amendment or the acceptance of the previous versions from the EC and the EP. On the 19th of June 2013, the Council Working Group reached an agreement [26] about its own variant of the limit values table that may be seen as a compromise between the two previous versions. Besides differences between the proposed limit values per vehicle (sub-) category, differences in the implementation time schedule exist between the three versions.

Category	Description	Total number of vehicles in database	Average difference of test results: method B – method A [dB(A)]
M 1	Passenger car	653	-2,1
M 1G	Pass. car – off-road	24	-2,3
M 2	Medium-sized bus	28	-1,0
M 3	Heavy bus	76	-0,7
N 1	Van	52	-1,7
N 1G	Van – off-road	3	-1,2
N 2	Medium-sized truck	55	-1,2
N 3	Heavy truck	100	+1,2
N 3G	Heavy truck – off-road	39	+0,6
Total		**1030**	**-1,5**

Table 3 - Average difference between noise emission test results according to method B and method A per vehicle category

Curently, the decision making process within the EU has nearly reached the conclusion. The three institutions — European Commission, European Parliament and EU Council — have engaged in a so-called early second reading. This was an effort to reach a common position by a series of three trilogue negotiations, which were held on October 1, October 15 and November 5, 2013. On the 5th of November, a provisional agreement was reached between the Lithuanian Presidency of the Council and representatives of the EU Parliament. The agreement was endorsed by the Committee of Permanent Representatives (COREPER) of the EU Member States that is responsible for the preparation of the work of the Council [30]. This agreement paves the way for the formal adoption of the new regulation, on which the European Parliament is expected to vote early 2014. The draft of the Regulation agreed upon [31] specifies a table of limit values that corresponds to the Council proposal.

3.1 Impact analysis of different limit value sets

In order to support the preparation of a Council decision, TNO was asked to evaluate the three versions of the proposal and to analyze the impacts with the same methods as used in the VENOLIVA study. The results of this analysis were reported in a memorandum to the Council Working Party on Technical Harmonisation [27], [28]. The version of the limit values set that has now been agreed upon is similar to the Council proposal.

This set of limit values will result in a reduction of L_{DEN} and L_{night} noise impact levels, averaged over a variety of road and traffic types of 2,5 dB(A). In due time, it will lead to a reduction of the number of highly annoyed resp. annoyed people by approximately 21% resp. 16%. This reduction of the traffic noise impact would bring a socio-economic benefit of 123 Billion Euro, while the raise of the development and production costs for industry would be 5,7 Billion Euro. This implies a benefit-cost ratio of 21 and amounts to a net present value of 117 Billion Euro. Reduction of vehicle noise emission will thus yield a considerable economic benefit for the member states of the European Union.

The final outcome could have been even more favorable and the final stage could have been reached sooner if the original European Commission proposal would have been accepted.

3.2 Future changes of the limit values

This very recent decision to modify the test method and to lower the limit values did cause a great deal of political discussion and revealed rather fundamental differences of opinion between the supporters of noise abatement and the supporters of industrial interests. Nevertheless, for insiders it is very clear that the effects of this limit value reduction will only constitute a small step on the long road towards substantial reduction of the impact of traffic noise. Therefore it would be advisable to decide not just on one small step, but on a long term strategy of regular reductions of the limit values. That would offer a much clearer perspective on the improvement of the urban environment in the long run, and it would give the industry the possibility to anticipate in an early stage on future requirements and develop the most economical methods to comply with these. A recommendation to initiate such a long term strategy was included in the VENOLIVA report, but unfortunately this recommendation was not adopted in the EC proposal.

Therefore, at this moment it is very difficult to predict when the next lowering of the limit values may be expected.

4. NEW DEVELOPMENTS CONCERNING VEHICLE NOISE TEST METHODS

Some years ago a concern arose about the low noise emission of electric and hybrid vehicles. When driving at low speeds in electrical drive mode these vehicles may be almost inaudible. This might cause traffic accidents when pedestrians or bicyclists do not hear an approaching vehicle. In particular visually impaired people were worried by this new threat to their traffic participation. As a result of the concern raised by organizations of blind and visually impaired persons, several states of the USA initiated new legislation, demanding a minimum noise emission during low speed driving and standstill. These new legal requirements were supported by the development by the SAE of a standard specifying a test method for minimum noise emission of vehicles. With the aim to attain international harmonization on this topic, it was submitted for discussion to the GRB of UNECE. Also, a new work item proposal for the development of an ISO standard on testing of minimum noise emission was submitted to ISO TC 43/ SC 1. Several ISO member bodies objected to the proposal because developing such a method would pave the way for introducing international requirements for a minimum noise production of road vehicles and would counteract the aim of achieving lower noise emission of road vehicles. In spite of these objections, the proposal was accepted by ISO TC43 and allocated to WG 42. Since 2009, a subgroup is working on the drafting of a test method (ISO 16254) that bears a strong resemblance to the test method of the old ISO 362. It will be based on outdoor testing on the same test track as is used for the type of approval tests for the (maximum) noise emission.

However, as the minimum noise levels are significantly lower than the noise emission during the type approval tests, the minimum noise test is much more sensitive to disturbing background noise than the normal noise test. That observation has triggered another new development in vehicle noise testing: the development of an indoor vehicle noise test procedure aimed at achieving an

acoustical correlation between exterior noise testing in a free-field anechoic test chamber and real outdoor testing. Another subgroup of WG 42 is working on this item since 2010. This development is aimed to achieve a perfect imitation of the classic outdoor pass-by test in an indoor test environment. The power train noise measurement during acceleration of the vehicle over a distance of 20 m on the test track is simulated on a dynamometer drum. The transient sound signal on the stationary microphone in the middle of the test track during the passage of the vehicle is simulated by scanning the signals received by an array of microphones positioned at regular intervals along the test rig.

For the addition of tire/road noise, two different variants are being developed:

- Variant A is based on separate measurement of tire/road noise on the test track at a range speeds and adding the level of the tire/road noise energetically to the power train noise level;
- Variant B is based on measuring the overall vehicle noise on the dynamometer and correcting the tire/road noise component to convert from indoor result to outdoor prediction.
- In the opinion of the authors this is a missed chance: the development of an indoor test method offers the possibility to create a fundamental change and to introduce an advanced test method based on an urban drive cycle, similar to the fuel efficiency tests for vehicles. The power train noise could then be measured without any contribution of tire rolling noise by simulating the engine load by direct coupling of the drive train to a chassis dynamometer. Moreover, the test result could be based on the sound power level instead of the maximum pass-by level. This would be an advantage if the test results are to be used for traffic noise impact computations.

Also, for the tire/road noise, a more innovative approach of sound power level measurements on a laboratory drum test bench would be possible, with similar advantages.

Unfortunately the subgroup focuses on imitating the outdoor test method with a rather simple set of operating conditions that still suffers from many limitations and drawbacks (e.g. the need for ASEP).

5. CONCLUSIONS

The new EU and UN/ECE vehicle noise emission limits and associated measurement methods may be seen as a final stage of a long series of developments towards a more representative way of testing, but at the same time they should be a starting phase of regular reductions of limit values in the future in order to achieve a substantial

reduction of traffic noise impact and improvement of urban environmental conditions.

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REFERENCES

[1] Commission proposal COM(2011) 856 for a Regulation of the European Parliament and of the Council on the sound level of motor vehicles, 2011/0409 (COD), 9 December 2011.

[2] EU Directive 70/157/EEC on the approximation of the laws of the Member States relating to the permissible sound level and the exhaust system of motor vehicles, Council Directive of 6 February 1970, Brussels, Official Journal L 042, 23/02/1970 P. 0016 – 0020.

[3] European Parliament legislative resolution of 6 February 2013 on the proposal for a regulation of the European Parliament and of the Council on the sound level of motor vehicles - European Parliament Amendment P7_TA-PROV(2013) 0041.

[4a] ISO/R 362: 1961 – Measurement of noise emitted by accelerating road vehicles, ISO, Geneva, 1961.

[4b] ISO 362: 1981 - Measurement of noise emitted by accelerating road vehicles – Engineering method, ISO, Geneva, 1981-10-01.

[4c] ISO 362-1: 2007 - Measurement of noise emitted by accelerating road vehicles – Engineering method, Part 1: M and N categories, ISO, Geneva, 2007-07-01.

[5] Commission Directive 81/334/EEC of 13 April 1981 adapting to technical progress Council Directive 70/157/EEC on the approximation of the laws of the Member States relating to the permissible sound level and the exhaust system of motor vehicle, O.J. L131/6, Brussels, Belgium, 1981.

[6] Commission Directive 84/372/EEC of 3 July 1984 adapting to technical progress Council Directive 70/157/EEC on the approximation of the laws of the Member States relating to the permissible sound level and the exhaust system of motor vehicles, O.J. L196/47, Brussels, Belgium, 1984.

[7] Council Directive 92/97/EEC of the Council of 10 November 1992 amending Directive 70/157/EEC on the approximation of the laws of the Member States relating to the permissible sound level and the exhaust system of motor vehicles, O.J. L371/1, Brussels, Belgium, 1992.

[8] ISO 10844 – International Standard for the specification of test tracks for the purpose of measuring noise emitted by road vehicles, ISO, Geneva, Switzerland, 1997.

[9] Commission Directive 96/20/EC of 27 March 1996 adapting to technical progress Council Directive 70/157/EEC relating to the permissible sound level and the exhaust system of motor vehicles, O.J. L092/23, Brussels, Belgium, 1996.

[10] Commission Directive 1999/101/EC of 15 December 1999 adapting to technical progress Council Directive 70/157/EEC relating to the permissible sound level and the exhaust system of motor vehicles, O.J. L334/41, Brussels, Belgium, 1999.

[11] Steven, H., Ermittlung der Geräuschemissionsänderung von Kraftfahrzeugen im Strassenverkehr, Report no. 105 05 140, FIGE GmbH, Herzogenrath, Germany, 1994 (In German).

[12] Sound Emission by Motor Vehicles on Motorways in The Netherlands, J.D. van der Toorn, T.C. van den Dool & J.A. van Vliet, Proc. InterNoise 2001, The Hague, The Netherlands, 2001.

[13] Beek, P. van, F. de Roo, M. Dittrich, Revision of the vehicle noise emission test method – a serious need for serious changes, Proceedings ICVS18, Rio de Janeiro, 10-14 July 2011.

[14] Biegstraaten, F.J.W., E Gerretsen, J.C. Tukker, Noise emission of passenger cars in urban traffic – The quality of the type approval test and the effect of changes in limit value or test method (in Dutch), Report no. 623.109, TNO Institute of Applied Physics, Delft, 27 February 1989.

[15] ISO 7188:1985, Acoustics – Measurement of noise emitted by passenger cars under conditions representative of urban driving, ISO, Geneva, 1985.

[16] Steven, H., Geräuschmessungen an PKW nach verschiedenen Messverfahren (in German), FIGE-Bericht 80-105 05 119/01, FIGE GmbH, Herzogenrath, Germany, May 1982.

[17] Steven, H., Verbesserung der Geräuschemissionsmessverfahren für Kraftfahrzeuge – Pkw, FIGE-Bericht 84-105 02 410/03, FIGE GmbH, Herzogenrath, Germany, November 1984.

[18] Sandberg, U., Noise Emission of Road Vehicles – Effect of Regulations, Final Report by the I-INCE Working Party on the Effect of Regulations on Road Vehicle Noise, Swedish National Road and Transport Research Institute (VTI), Linköping, Sweden, 2001.

[19] Steven, H. Investigations on Improving the Method of Noise Measurement for Powered Vehicles, Report Number 10506067 by order of the Germany Federal Environmental Agency, August 1999.

[20] Steven, H. Further Noise Reductions for Motorized Road Vehicles. Presentation within the Workshop of the German Federal Environmental Agency, September 2001.

[21] Regulation No 51 – Addendum 50 – Revision 1 – Uniform provisions concerning the approval of motor vehicles having at least four wheels with regard to their noise emissions, Regulation UN/ECE, Geneva, Switzerland, 30 May 2007.

[22] EU Directive 2007/34/EC amending, for the purposes of its adaptation to technical progress, Council Directive 70/157/EEC concerning the permissible sound level and the exhaust system of motor vehicles, Commission Directive of 14 June 2007, Brussels, Official Journal L 155, 15/06/2007, P. 49 – 67.

[23] De Roo, F., Dittrich, M, et al. VENOLIVA - Vehicle Noise Limit Values - Comparison of two noise emission test methods, Final report, TNO report MON-RPT-2010-02103, 30 March 2011. http://ec.europa.eu/enterprise/sectors/automotive/environment/noise/index_en.htm

[24] Regulation (EC) No 661/2009 of the European Parliament and of the Council of 13 July 2009 concerning type-approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units intended therefore, Official Journal L200, 31/07/2009, P. 1 – 24.

[25] De Roo, F., Dittrich, M. et al., Influence of tyre-road noise on road vehicle type approval test results, Proceedings Forum Acusticum 2011, Aalborg, Denmark, June 2011.

[26] Document 11319/13ENT 198 ENV 620 MI 569 CODEC 1548, Council of the European Union, Brussels, 21 June 2013.

[27] De Roo, F., Dittrich, M., EU Regulation on the sound level of motor vehicles – Impact analysis of various limit values sets for the purpose of decision making, Memorandum TNO-060DNV-2013-01069, TNO Technical Sciences, The Hague, 9 May 2013.

[28] Dittrich, M., Roo, F. de, Potential Impact of Latest Proposals for New European Vehicle Noise Limits, Proceedings AIA-DAGA, Merano, Italy, 18-21 March 2013.

[29] De Roo, F., New EU and UN/ECE Vehicle noise emission limits and associated measurement methods, Keynote Paper, Proceedings InterNoise 2013, Innsbruck, Austria, 15-18 September 2013.

[30] Noise limits for motor vehicles, Press release 16326/13, Council of the European Union, Brussels, 15 November 2013; http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/intm/139612.pdf .

[31] Regulation (EU) No. …/... of the European Parliament and of the Council on the sound level of motor vehicles - Text as approved by COREPER on 15 November 2013, document ENVI20131127, European Parliament, Brussels, November 2013; http://www.europarl.europa.eu/meetdocs/2009_2014/documents/envi/dv/envi20131127_csl_soundlevel_vehicles_/envi20131127_csl_soundlevel_vehicles_en.pdf .