

VEHICLE NOISE

SETTING THE RIGHT SOUND LEVELS

European Automobile Manufacturers Association

Different kinds of cars should be classed differently

- The categories need to be refined to encompass vehicle types, use and technical differences
- 'Performance' class vehicles (M1b category) are a relatively small niche - costs are unevenly distributed
- 'Special performance' class vehicles (**M1c** category) have special characteristics and specific customer appeal

NEW CATEGORISATION PROPOSED BY ACEA



Vehicles of different classes require tailored design

BREAKDOWN OF PASSENGER CAR REGISTRATIONS (50)

and would fall into the M1a category

99%

solutions

Vehicle classes should be adapted to accommodate these requirements



Different kinds of cars should be classed differently

All passenger cars, from small hatchbacks to sports cars, large luxury saloons and 9-seat people carriers fall into the M1 regulatory category, with varying requirements for sound levels. This broad categorisation of diverse 'vehicle families' introduces significant problems when regulation requires the application of specific technologies to all vehicle types across many families.

To improve the situation, both the industry and the Commission have proposed a passenger car classification system which is dependent on the power-to-mass ratio of the different vehicle families. The Commission's proposal suggests dividing the classification into two levels, respectively below and above 150 kW/t.

The industry's proposed classification, shown here, divides the existing M1 category into 3 segments, with 99% of vehicles falling into the green 'normal' category. The other two categories are for niche vehicles, which make up a tiny proportion of the vehicles on the market.

The reason for the separation of the blue and red categories reflects the differences between 'performance' cars and 'special performance' sports cars. Those in the blue category are a cross-over between power and driveability, sometimes with uprated powerplants but based on 'normal' production types. By contrast, the red category 'special performance' category groups together dedicated sports car families, designed from the outset to be highpower and high-performance.

It is important to underline that the vehicle families represented in the blue 'performance' and red 'special performance' categories make up as little as 1% of registrations. Their rarity and uniqueness means that reducing the sound level to the Commission's proposed level is not cost effective, given the small contribution that the class makes to overall noise levels.



Trucks come in many different shapes & sizes

- Truck types have many variations: regulatory changes have multiple impacts across all vehicle 'families'
- To cater for differences ACEA proposes three categories:







The industry's proposed new classification reflects diverse product families and a wide variance of styles, applications, types, models and ranges according to customer demand



Trucks come in many different shapes & sizes

Commercial vehicle families are even more diverse than passenger cars, and within the N2/N3 categories there are a large number of technically distinct types. Commercial vehicles perform a wide variety of missions, across different sizes and ranges. Whereas 13-15 million passenger cars are registered per year in the EU, the number of commercial vehicles is far smaller in absolute terms – around 340,000 units per year – with more specific types. This means the cost of compliance to uniform regulation per family is very significant, as even small changes have their impact multiplied across all vehicles in that family.

The range of possibilities and the extent of variable customer demand mean that sub-categories are a necessity, taking into account special purposes or urban, non urban, on- or off-road use.

The categories proposed here are designed to cater for the variations between commercial vehicle families. As can be seen from the pictures, the green, blue and red categories cover vehicles of vastly different lengths, rated power levels, axle numbers, load, geography and customer applications. For this reason, it is important to divide the families in a consistent way.

The classification of commercial vehicles needs to be brought into line with the number of vehicle types available today, and be 'future proofed' against technological developments.





Sound limit proposals for M1 passenger cars

Staging of implementation allows systematic and cost effective distribution of investment costs and development efforts



Sound limit proposals for M1 passenger cars

The industry proposes limits that reflect the range of technical, economic and consumer preference considerations. The industry's proposal is not a contrast to the recent European Commission initiative, but rather demonstrates the proportion of vehicles that are encompassed in given stages.

In fact, the Commission's 68dB(A) second stage proposal for 'normal' cars – those below 150kW/t – would actually require all passenger car families to be quieter even than some existing battery electric vehicles, and affects nearly 90% of existing families.

The three-category approach advocated by the industry means that the limits better reflect the characteristics of the vehicle. For instance, the Commission's stage 2 proposal for 'special performance' vehicles actually covers 100% of all vehicles in that class, which is heavy-handed – as well as being counter to consumer preferences. The industry proposal caters for the difference of vehicles in this 'special performance' category.

This industry-proposed classification is consistent with the existing test method for noise, in which there is no uniform requirement for all vehicles. The format of the test the vehicles must complete is identical regardless of power, but the acceleration the vehicle is required to perform is dependent upon the power to mass ratio. These will necessarily generate different sound levels and the new categories allow for a better distinction between requirements for different vehicle types.

This segmentation also allows, where necessary, for the general transposition of advanced technologies into mass production, without adversely affecting the viability or design of economical or smaller segment vehicles.





Sound limit proposals for N3 heavy-duty trucks

Staging of implementation allows systematic and cost effective distribution of investment costs and development efforts



Sound limit proposals for N3 heavy-duty trucks

Commercial vehicle limit values need to reflect commercial vehicle diversity, and the industry proposal caters for the differences in role, length, load, power and so on. This avoids the situation that would occur under the Commission proposal, whereby 100% of very large multi-axle N3 category trucks would be covered, applying the same requirements as suggested for trucks half their weight, size and power.

As with the passenger cars, the limit is only half the story: the most challenging aspect of motor vehicle sound reduction is not just the lead-time, but proportion of vehicle families affected by the change. The sound levels of respective motor vehicle families are distributed across a range, and the limit value needs to account for the proportion of vehicles that are affected. A limit value that is too low will increase the immediate pressure on research and development while concurrently diluting the ability of the R&D facilities to concentrate on specific technical challenges.

It is for this reason that the industry-proposed limit values appear higher than those of the Commission. This structure, with a shorter lead-time to stage 1, captures the 'peak' vehicles across the categories, but then allows the lead-time sufficient to engage the more complex technical challenges that occur across the different vehicle families.

Finally, the stage 2 level set by the Commission is fundamentally unrealistic given the provisions of the General Safety Regulation 661/2009/EC which specifies tyres during the test that have a noise level of 74dB(A) when under torque. In practice this means that the total input from powertrain, body, suspension and related components must be less than 67dB(A), which presents certain intractable problems. This is the reason for the 81dB(A) industry proposal for the 'heavy' N3 category over 250 kW, which is an achievable level, encompassing ≈50% of all vehicle-families in this class.



Engineering complexity requires appropriate lead-time





The total vehicle noise derives from several sources (engine, intake, powertrain, exhaust, tyres, etc)

In reducing noise levels, modification of single elements necessitates subsequent redesign of other components



Engineering complexity requires appropriate lead-time

Vehicles are complex devices with thousands of

integrated components: reduction in the sound level of one part requires the further development and possible redesign of related elements.

The sound a vehicle makes when it passes is a combination of these inputs, but includes other factors such as the environment, road surface resistance, air turbulence and so on.

Advances in technology mean that combustion engines are much quieter than before. Modern vehicles are 90%+ quieter than those from 40 years ago. Many of the possible avenues for further noise reduction are actually to be achieved by addressing the non-vehicle inputs, such as the road surface, the infrastructure and the tyres.

67dB(A) of the noise from a passenger car under type-approval conditions is from the tyres. Since stage 2 of the Commission proposal is 68dB(A) from the whole car, this places a severe restriction upon the noise that can be produced by the rest of the vehicle.

To put this into perspective, the average noise level from an electric vehicle is around 68dB(A), which implies that the Commission would like to ensure that all vehicles are this quiet.

Nonetheless, certain noise reductions can be achieved through the research and development of improved production techniques and components – but these require significant lead-times and a great deal of investment. Once designed, developed and built, manufacturers need vehicles to remain largely unchanged during their production cycle, in order to recoup capital costs.

The development cycle of most vehicle manufacturers is in the order of 7-8 years long, so lead-times need to be comparable, and fit into the cycle. Regulations need to arrive at a time during which they can still be implemented into the vehicle, between the 2-3 year feasibility/package phase and the 4-5 year long component development cycle.



Engineering complexity requires appropriate lead-time





Every system is composed of several interdependent components so any modification to reduce noise requires fundamental redesign of other parts



Engineering complexity requires appropriate lead-time

The many sources of noise from a vehicle are

demonstrated on these truck and car schematics. The six major sources of vehicle noise are shown as coloured discs, and are indicated on the cutaways of the car and truck. The height of the various elements is an indication of the relative input of that source to the sound level of passenger cars at 50km/h and heavy-duty vehicles between 35-40km/h in urban driving.

At these speeds, passenger car tyres are a major influence on vehicle noise. Rolling noise is more significant for passenger cars than for heavy-duty vehicles. For trucks, which can easily double their weight in cargo, the load influence of the tyres can be significant.

The engine is an obvious source of noise, and in combination with the powertrain there are a large number of interlinked components that produce sound. These include rattles and sound pressure waves, but also include vibrations and 'surface radiation', which is the low-frequency sound produced by a surface as it pulsates, like a drum.

The 'mechanics' of noise mean that as the sound level of any individual component is reduced, others become more noticeable – which means that all components must be worked on together to actually reduce engine (and vehicle) noise.

This is also true for other noise producing vehicle elements. For instance, the reduction of powertrain and exhaust sounds can bring to the fore the influence of aerodynamic resistance noise or previously unnoticed body movements.

Accordingly, when responding to the requirements to make a vehicle quieter, the realities of noise reduction efforts have to include lead-times that respect the complexity of the engineering involved.



Sound reduction requires joint action

- Traffic sound is much more than just vehicles
- Vehicles cannot be looked at in isolation
- Many factors affect how much noise is produced



Driving behaviour

How a vehicle is driven strongly influences vehicle sound emissions

Sound tuning

Vehicles can be louder than designed by the manufacturer, especially if unauthorised parts are used.



Traffic management

Improved traffic flow reduces sound levels

Road surface

Different surfaces can have different noise characteristics (cobblestones/asphalt/concrete)

To realistically comply with sound level reduction targets, there must be joint effort implemented through an integrated approach, bringing together driver education, enforcement, management and infrastructure



Sound reduction requires joint action

Vehicle manufacturers support the aim of traffic noise reduction, and are contributing with established and ongoing noise reduction vehicular performance work. Indeed, for most vehicle types, customers are demanding quieter and more comfortable vehicles. However, efforts to increase customer comfort and to reduce interior sound levels necessarily have a positive effect on exterior noise measurements.

Tyre noise and aerodynamic resistance are important factors in traffic noise, particularly in high density traffic. It is the tyres' interaction with the road surface that most determines how much noise the passage of a vehicle makes. While the vehicle type-approval test assumes that the road surface is smooth and flat (creating an engine noise bias), the reality is that road surface quality and state vary significantly and are source of noise. Often roads are rough to provide grip, or are made of concrete, which is long lasting but can be up to 10 dB(A) louder than the road surface used in the test.

Vehicle noise is also partly to do with driver behaviour. A well maintained car driven smoothly will be considerably quieter than a poorly maintained vehicle driven aggressively. Additionally, the use of components or modifications – whether permissible or unauthorised – can have adverse effects on vehicle noise. Any reductions in traffic noise can be obliterated if there is inadequate control over noisecausing vehicle elements.

Road infrastructure design also has a large part to play in traffic noise reductions. Roundabouts are much more effective at managing traffic flow when compared to traffic lights, which require cars to brake, idle and accelerate. Improved traffic flow reduces the variations of the sound levels.

Further advance in noise reduction requires cooperation beyond just automobile manufacturers, including regulatory shifts, progress by tyre producers and by road builders. Further, changes to some components will have an impact on other vehicle outputs. For instance, modification of exhaust silencers to reduce noise may have a negative impact on vehicle fuel efficiency – increasing the environmental impact. Smaller tyres reduce rolling noise, but mean smaller brakes and reduced grip, with obvious implications for road safety. However, with an integrated approach, covering all inputs, vehicle noise can be reduced.

Need for appropriate sound levels - quiet can be too quiet -

- EC proposal would make internal combustion engine (ICE) cars quieter even than battery electric vehicles (BEV)
- In urban traffic conditions, battery electric vehicles are regarded by the EC as being too quiet
- The EC recommends fitment of an acoustic device at low speeds for safety reasons

COMPARISON OF PASSENGER CAR SOUND LEVELS AT 50KM/H WITH PROPOSED STAGE 2 LIMITS



The proposed limit value of 68db(A) by the EC is not an appropriate limit value for type-approval of internal combustion engine cars



Need for appropriate sound levels – quiet can be too quiet

Vehicle noise should not only be considered as a nuisance. The noise made by a moving vehicle is also important in alerting nearby pedestrians to an oncoming cars, buses or trucks.

This is particularly the case for the blind or visually impaired, as they use the noise emanating from vehicles on the road to determine their location and direction of travel.

Pedestrians are more likely to be in the presence of electric vehicles in relatively slow moving urban zones, where speeds are supposed to be not higher than 50 km/h. At these speeds and in such environment, electric vehicles can be inaudible.

Electric Vehicles are now being criticised for failing to alert pedestrians, and manufacturers are being invited to fit noise-making devices to counter the inherent silence of the electric powertrain.

The electric powertrain is quieter than the equivalent internal combustion engine, but the rest of the vehicle technology is largely the same. This means that electric vehicles are quieter than 'traditional' engine vehicles only up to speeds of between 20-30 km/h. Above this, and at the type-approval test speed of 50 km/h, wind noise and tyre rolling resistance account for a greater proportion of noise, regardless of vehicle powertrain. The typical type-approval test result for electric vehicles is 68dB(A), with a variation of +/- 2dB(A).

The EU Commission is proposing limit values of 68dB(A) at the second stage after the publication of the regulation, which means that combustion engine passenger cars would be required to be as silent as electric vehicles.

A result of this proposal is the contradictory possibility that internal combustion engine passenger cars become as quiet as electric vehicles, putting manufacturers in the ironic situation of potentially having to fit noise-making devices to all vehicles they have been forced by legislation to quieten.

While lower limits are certainly desirable, particularly if they equilibrate the difference between electric and combustion engine vehicles – this is a long term solution. In the short-to-medium term, vehicles noise limits need to have a minimum which is sufficient that they remain detectable in existing traffic conditions.

A closer look at stage 2 for heavy-duty vehicles over 250kW

- In order to reduce the sound level to 78 dB(A) as proposed by the EC, noise sources such as the engine and gearbox must not have a higher noise level than 67 dB(A)
- Existing heavy-duty trucks with internal combustion engines cannot reach EC proposed sound level in the foreseeable future

TEST ON HEAVY-DUTY VEHICLES USING TYRES SPECIFIED BY GENERAL SAFETY REGULATION (661/2009/EC)

- fading indicates a distribution of output levels -

Tyre noise under torque | Souther vehicle noise, including engine, etc.



For internal combustion engine heavy-duty trucks over 250 kW, ACEA recommends a realistic & cost-effective noise level reduction to 81dB(A)



A closer look at stage 2 for heavy-duty vehicles over 250 kW

Imagine a heavy commercial vehicle with no engine or gearbox, but with a power output of more than 250 kW and with the corresponding torque of the powertrain when loaded during full throttle acceleration. This is a "rubber band" (RBV) heavy commercial vehicle. The sound emission of this vehicle during the pass-by noise test would only be determined by tyre road noise under torque. Equipped with tyres according to the technology requested by the General Safety Regulation (661/2009/EC) this vehicle would produce a sound emission of at least 74 dB(A).

Now imagine that this vehicle is equipped with an electrical engine only driven by batteries. The sound emission related to the tyre interaction with the road surface under torque will be slightly higher than for the rubber band heavy commercial vehicle because the torque produced by an electrical engine is always somewhat higher than the torque coming from an internal combustion engine. Additional, there are new noise sources in the form of the electrical engine, the hydraulic pump for the power steering, the air compressor for the brake system and the cooling systems to control the climate around the batteries. This vehicle would produce a sound emission of at least 78 dB(A).

The stage 2 Commission proposal requests a heavy commercial vehicle noise limit of 78 dB(A).

This would imply that a heavy commercial vehicle, driven by an internal combustion engine with more than 250 kW and equipped with the same tyres as the rubber band heavy commercial vehicle, would produce no more sound than the battery electric equivalent. Consequently, the sound emission from only the internal combustion powertrain cannot be higher than 67 dB(A).

Can the best technology known in the near or even far future produce less than 67 dB(A)? Given that this type of engine must simultaneously fulfill future gaseous emissions levels and consume less fuel, the answer to this question is currently "no".



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