Submitted by the expert of OICA

Informal document **GRBP-76-14**
76th GRBP, 5-7 September 2022
Agenda Item 2

Comparison of EMISIA and ATEEL study on sound limit values for vehicle category M & N

Review study performed by ATEEL on behalf of ACEA / OICA

76th GRBP

Comparison of EMISIA and ATEEL studies on sound level limits of M- and N-category vehicles

Study results | 76th GRBP | 5-7 September 2022

Content of presentation

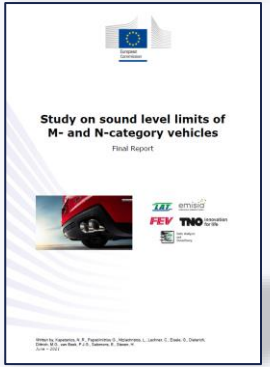
- Comparison of study approaches and findings
  ATEEL – EMISIA study
- Impact calculations for limit value scenarios and alternative measures using ATEEL simulation tool
- Representativeness of type approval values for real traffic situations differing from type approval conditions
- Conclusions and recommendations

Comparison of study approaches and findings ATEEL - EMISIA

Comparison of study approaches

ATEEL study focus

- Analysis of survey feedback from technical entities
- Development of realistic vehicle sound models per category and limit phase
- Benefit analysis of a further limit value reduction beyond phase 3 for real traffic conditions
- Evaluation of alternative measures (tyre road interaction / speed limits / road / market penetration)



EMISIA study focus

- Analysis of survey feedback from technical entities and social partners
- Evaluation of reduction potential beyond phase 3 limits
- Cost Benefit Analysis (CBA) of several potential scenarios and combination of scenarios
- Proposal of new limits and reflection on potential revision of the test procedures

- Focus ATEEL study: Achievable benefits (L_{Aeq}) by theoretical limit reductions (no cost analysis)
- Focus EMISIA study: Costs and benefits for society by limit value reductions or changes in TA procedure

Review of survey feedback

ATEEL understanding of feedback from technical entities

- Feedback given to EMISIA and ATEEL is almost identical
- “Technical limit”* for most vehicle categories already reached with Phase 3 limits
- Lowering limits without the availability of significantly quieter tyres are not considered possible
- Even most EVs would struggle to meet limit values below phase 3 due to tyre sound
- Test procedure needs to be reviewed in specific fields (measurement uncertainties, hybrid vehicles, RD ASEP)

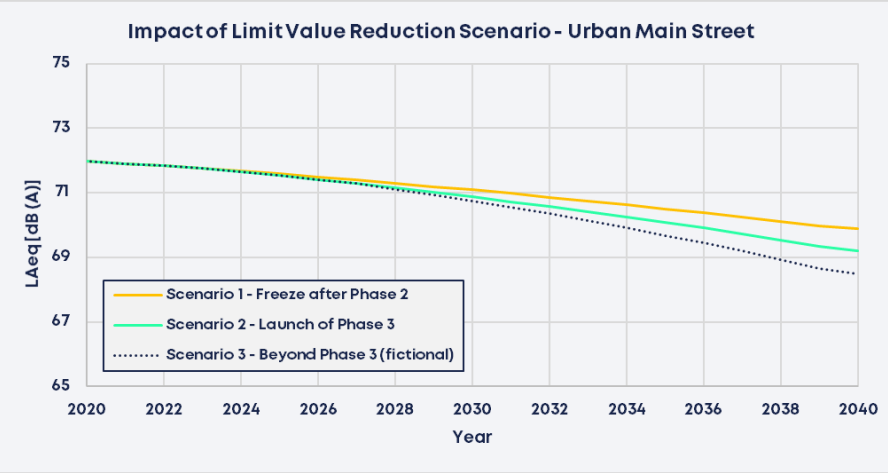
* *"technical limit": further exterior sound reduction creates according to industry inacceptable trade-offs in other disciplines*

ATEEL understanding of feedback from social partners

- Mainly emotional feedback without consideration of technical progress
- Focus on single events, manipulated or defect cars, bad driving style, over speeding etc.
- **But** traffic issues like bad driver behaviour or increasing traffic density cannot be solved by lower type approval values

- Feedback from technical entities: Technical limit already reached with phase 3 (in line with feedback received by ATEEL)
- Feedback from social partners: Most observations are based on single events and not linked to type approval procedure

ATEEL scenarios and approach



Source: ATEEL Study on future sound limit values for type approval for vehicles of category M & N (2022)

Reminder - Scenarios as used in ATEEL calculation

- Scenario 1
  Freeze limits after implementation of phase 2
- Scenario 2
  Launch of phase 3 limits as foreseen
- Scenario 3
  Further limit reductions beyond phase 3
  limits reduced by -2 dB(A) (4 years after phase 3)

Remarks

- Compliance with limits of scenario 2 and 3 improvements on powertrain (PTR) and tyre rolling sound (TR) is assumed
- Scenario 3 is fictional (“what would it bring if we could”) as feasibility is not confirmed by vehicle and tyre industry
- Market growth was not considered in the ATEEL study since the differences between the scenarios are important

EMISIA scenarios and approach

Scenario	Definition by EMISIA as understood by ATEEL	Comments from ATEEL	Comparability of approaches
0 - Baseline	Vehicle limits (acc. EU 540/2014 incl. phase 3) and tyre limits (acc. EU 2016/1350 stage 2)	Unclear which sound levels are assumed; Contradictory information is provided	Somewhat comparable to ATEEL scenario 2; No progress on tyres considered in EMISIA study
A - Available limit space	-1 dB(A) for all categories (Phase 4) (progress assumed exclusively via powertrain)	Provides a maximum benefit of 0.3 dB(A); Limits finally proposed less demanding especially for vehicles with high traffic share (e.g. M1-a representing 98% of M1)	Somewhat between ATEEL scenario 2 and 3; ATEEL study conclusion: lower limits beyond phase 2 are only feasible with contribution of tyres
B - Targeted limit tightening	-1 dB(A) for all categories but -2 dB(A) for busses, lorries and trucks (Phase 4) (progress assumed exclusively via powertrain)	Provides a maximum benefit of 0.5 dB(A); Limits finally proposed widely less demanding	Somewhat comparable to ATEEL scenario 3; No progress on tyres considered in EMISIA study

EMISIA scenarios and approach

Scenario	Definition by EMISIA as understood by ATEEL	Comments from ATEEL	Comparability of approaches
C - 75 dB(A) cap	-3 dB(A) Lwot limits for M3 & N3	Unclear what is proposed in detail	No such scenario in ATEEL approach
D - Lwot restrictions	Limits on Lwot for all categories by 2030	Of minor relevance in all traffic scenarios (intermittent and fluent)	No such scenario in ATEEL approach
E - Improved pass-by-test	Better representation of powertrain noise without changing the limits	Question of realistic/representative accelerations for real traffic; Intermittent traffic forces all vehicles into similar operating conditions (even the ones with high PMR)	Not considered in ATEEL approach; Would be a step back to UN R51.02
F - Quieter tyres	Tighter tyre noise limits by -3 dB(A)	Provides best benefit up to 1.9 dB(A) in non-urban conditions; -3dB(A) progress assumed immediately even for quietest tyres	ATEEL conclusion from tyre industry feedback: Squeeze out of noisiest tyres via uncertainty optimisation; Progress on quietest tyres is unlikely

Calculated benefits of EMISIA scenarios

Scenario	Lden		Lnight		ΔLden		ΔLnight	
	Urban	Non-urban	Urban	Non-urban	Urban	Non-urban	Urban	Non-urban
0. Baseline	59.4	67.2	50.8	58.5	-	-	-	-
A. Available limit space	59.1	67.1	50.5	58.4	-0.3	-0.1	-0.3	-0.1
B. Targeted tightening	59.0	67.0	50.4	58.4	-0.4	-0.1	-0.5	-0.2
C. 75 dB(A) cap	59.1	67.0	50.4	58.4	-0.3	-0.1	-0.4	-0.1
D. LWOT restrictions	59.2	67.1	50.5	58.4	-0.2	-0.1	-0.3	-0.1
E. Improved test	59.0	67.0	50.3	58.4	-0.5	-0.1	-0.5	-0.2
F. Quieter tyres - 3dB	57.9	65.2	49.4	56.6	-1.5	-1.9	-1.5	-1.9
Scenario A & F	57.5	65.1	48.9	56.4	-1.9	-2.1	-1.9	-2.1
Scenario B & F	57.3	65.0	48.7	56.3	-2.1	-2.2	-2.2	-2.2
Scenario A & E	59.0	67.0	50.3	58.4	-0.5	-0.1	-0.5	-0.2
Scenario B & E	58.8	67.0	50.2	58.3	-0.6	-0.2	-0.7	-0.2
Scenario D & E	59.0	67.0	50.3	58.4	-0.5	-0.1	-0.5	-0.2
Scenario E & F	57.3	65.0	48.7	56.4	-2.2	-2.2	-2.1	-2.2

Source: EMISIA Study on sound level limits of M- and N-category vehicles (2021) – page 220

ATEEL comments/conclusions on EMISA scenarios A to E

- Max. -0.5 dB(A) benefit compared to baseline – reached by only PTR measures and adaptation of the test procedure
- Not realistic since powertrain sound reductions of min. 3 to 5 dB(A) would be required to comply
- Only road types with intermittent traffic (1&3 in CBA) have potential to benefit from lower PTR sound

ATEEL comments/conclusions on EMISA scenario F

- Max. -1.9 dB(A) benefit compared to baseline – reached by only TR measures
- Road types with free flowing traffic (2 & 4) and/or higher speeds (5 to 8) benefit almost exclusively from tyre noise reduction

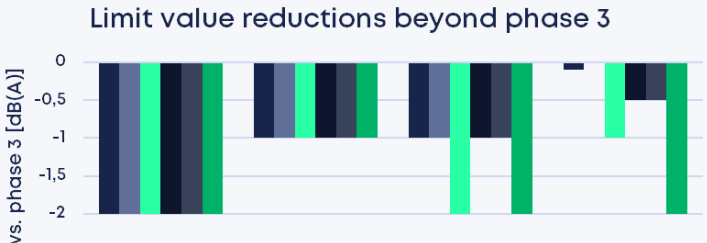
- Highest benefits for real traffic expected from quieter tyres and/or usage of low noise asphalts
- Progress on vehicles/powertrains only expected in conjunction with quieter tyres and/or better asphalts

Comparison of calculation models

ATEEL study	EMISIA study
Individual benefit display for each road type, driving speed, traffic condition (intermittent, free flow)	One single value calculated for a combination of 8 street types with significantly different boundary conditions
Calculations based on most realistic assumptions derived from TA databases, literature, EU registration data, etc.	Calculations based on the assumption that vehicles are all just in line with limit values? – not fully clear
Sound levels calculated with an emission model – reference to the type approval microphone distance at 7.5 m	Sound levels calculated for facade levels – source to receiver distance differs for different streets
Efficiency comparison of PTR/tyre measures with alternative measures (e.g. speed limits, silent asphalt)	ATEEL did not find any detailed discussion about alternative measures being included for comparison during review
Sensitivity analysis in order to understand impact of wrong assumptions in input parameters (“extreme scenarios”)	No sensitivity checks found by ATEEL during review
Individual simulations specifically for individual vehicle category (e.g. only N3) or type (e.g. only EV) possible	No individual discussions found by ATEEL during review

Impact calculations using ATEEL simulation tool

Comparison of limit value reductions



	ATEEL	EMISIA CBA Scenario A	EMISIA CBA Scenario B	EMISIA final proposal
M1	-2	-1	-1	-0,1
M2	-2	-1	-1	0
M3	-2	-1	-2	-1
N1	-2	-1	-1	-0,5
N2	-2	-1	-1	-0,5
N3	-2	-1	-2	-2

Remarks:

Vehicles of categories M1 and N1 create about 80 – 95 % of the traffic volume, dependent on traffic scenario

ATEEL has aggregated EMISIA final proposal for individual sub categories to the major vehicle categories for better comparison

ATEEL limit value scenario 3

- Most stringent limit reduction scenario beyond phase 3
- Non-confirmed fictional scenario based on the assumption that PTR and TR measures are required to comply

EMISIA CBA scenario A and B

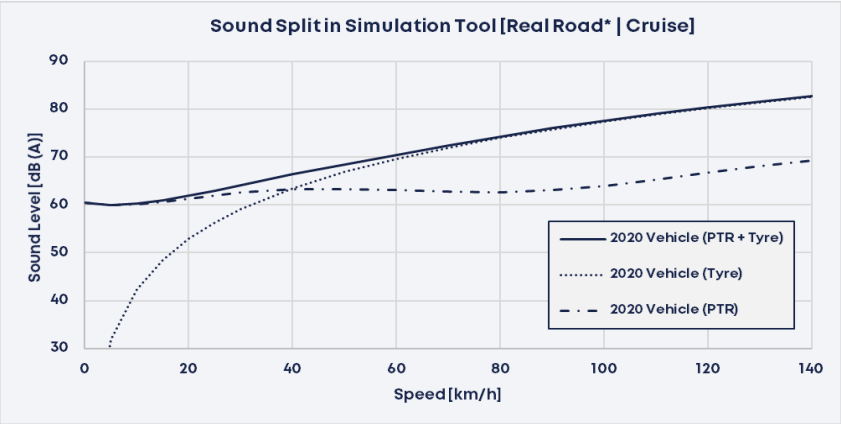
- Realised only by PTR measures – unfeasible high PTR reduction required according to assumptions of ATEEL scenario 3

EMISIA final proposal

- Based on feasibility assumptions after evaluation of TA data and measurement data
- N3 vehicle reductions appear unrealistic high – margin TA value vs. limit is required for good reason

➢ Marginal benefits expected based on the EMISIA final proposal limit value reductions (< 0.1 dB(A))

Comparison of ATEEL tyre model and EMISIA measurements



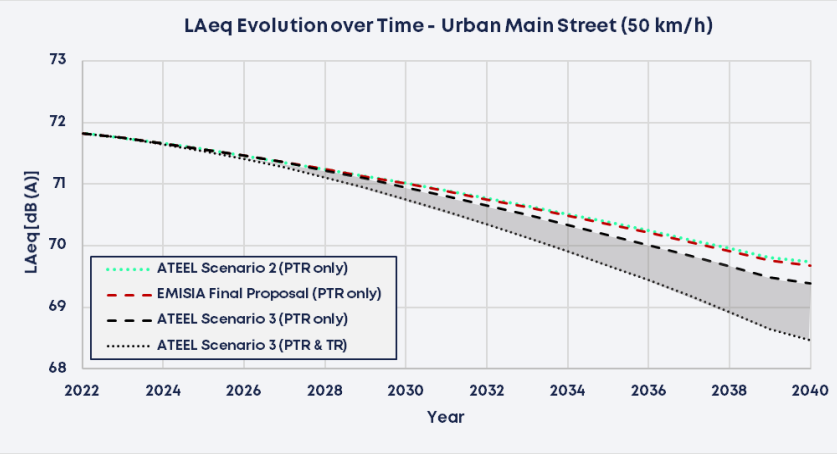
* Real road surface is set +3 dB(A) louder than ISO (similar to CNOSSOS)

M1 ICE vehicle – Real Road*

- EMISIA study measurements show a tyre rolling sound of ~67 dB(A) at 50 km/h coast-down on ISO track
- ATEEL tyre model is relatively on the quieter side compared to the measurements in the EMISIA study
- ATEEL tyre model for ISO surface is about 3 dB(A) lower than the measurements in the EMISIA study
- In the EMISIA measurements, the TR sound and the whole vehicle cruise sound level, are almost at the same level
- This confirms that the powertrain contribution is already lower than assumed in the ATEEL model

➢ A further reduction of only the powertrain would shift the balance further towards the tyres, even for lower driving speeds

Comparison of scenarios using ATEEL tool



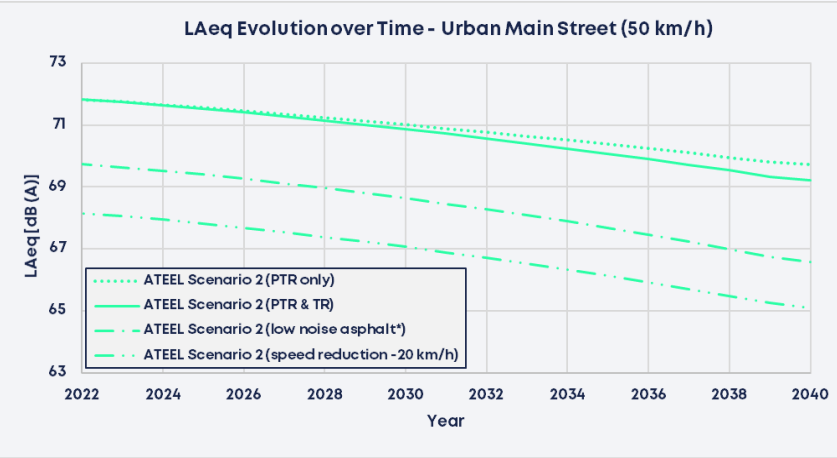
Year	ATEEL Scenario 2 (PTR only)	EMISIA final proposal (PTR only)	ATEEL scenario 3 (PTR only)	ATEEL scenario 3 (PTR & TR)
2022	71.83	71.83 (±0.00)	71.83 (±0.00)	71.83 (±0.00)
2040	69.73	69.68 (-0.05)	69.39 (-0.34)	68.47 (-1.26)

ATEEL scenario 3 and EMISIA final proposal

- As expected the EMISIA final proposal provides significant less benefit compared to ATEEL scenario 3
- Comparison of both ATEEL scenarios 3 shows that the main benefit is achievable by TR improvements
- The theoretical benefit achievable by only PTR measures is comparatively very limited
- The shaded area represents the uncertainty regarding customers tyre choice
- All findings even more pronounced at higher driving speeds due to more dominant rolling sound

➢ Achieved tyre optimisations will only lead to the expected progress if customers replace worn tyres with equally quiet tyres

Comparison to alternative measures



Year	ATEEL scenario 2 (PTR only)	ATEEL scenario 2 (PTR & TR)	ATEEL scenario 2 (low noise asphalt*)	ATEEL scenario 2 (speed reduction -20 km/h)
2022	71.8	71.8 (±0.0)	69.7 (-2.1)	68.1 (-3.7)
2040	69.7	69.2 (-0.5)	66.6 (-2.6)	65.1 (-4.1)

ATEEL scenario 2 combined with alternative measures

- Use of low noise asphalt* can significantly reduce the tyre rolling sound (dominant partial sound source)
- Implementation of speed limit reduction by only 20 km/h would have an even higher impact
- Immediate effect (no time delay due to required market penetration)
- Affect all vehicles, even the older ones (not only new vehicle types)
- Opportunity to use only locally in critical areas and to scale according to the required noise reduction

* -2 dB(A) below ISO 10844 asphalt

➢ Compared to limit value reductions, alternative measures show an immediate effect with high efficiency by addressing the dominant partial sound source and affecting all vehicles

Representativeness of type approval values for real traffic situations

Representativeness of type approval values for real traffic situations

- **Comment from Germany on 75th GRBP (February 2022)**
  How representative are type approval of vehicles with variable sound adjustment technologies for real traffic conditions?

- **Context of the question**
  Do type approval data gathered under R51.02 and R51.03 allow sufficient predictions of vehicle sound in real traffic?

- **The difficulty**
  Type approval testing takes place at certain specific driving conditions and may not cover all potential driving conditions in real traffic

- **The approach to adequately reflect on the comment from Germany**
  Comparison of both regulations UN R51.02 and UN R51.03 and analysis of representativeness of each regulation for real traffic

Main differences between UN R51.02 and R51.03 (light vehicles)

UN R51.02	UN R51.03
Only full load acceleration (not realistic for real driving)	Combination of full load acceleration and constant speed with 2/3 share of full acceleration
No acceleration requirements (high performance vehicles criteria - $\Delta v > 11$ km/h)	Acceleration requirements in dependency to PMR with a maximum of 2 m/s^2
Test gears only 3rd (or 2^{nd} & 3^{rd}) (MT) respectivley D (AT)	Test gears defined by their acceleration performance relative to the mandated acceleration performance $a_{wot\ ref}$
Combined results only in case of 2^{nd} and 3^{rd} gear via average	Weighted results regarding gears (k) and load (k_p)
Correction of result by -1 dB(A) and round off (down)	Mathematically rounded to the nearest integer and no correction.
No off cycle provisions	ASEP to avoid “noise defeat devices” beside TA point

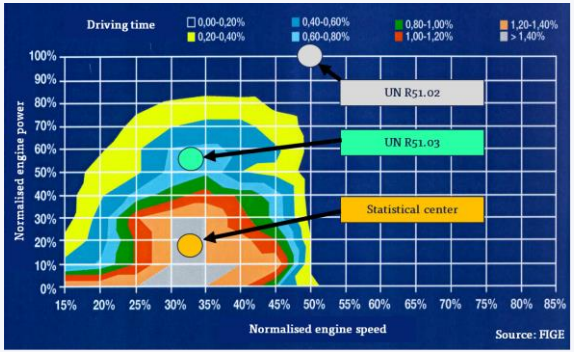
- R51.02 type approval results are higher than R51.03, especially for manual transmission (for trucks the other way around)
- R51.03 changes are aiming for a better representation of vehicle behavior in real traffic conditions

Main differences between UN R51.02 and R51.03 (medium and heavy vehicles)

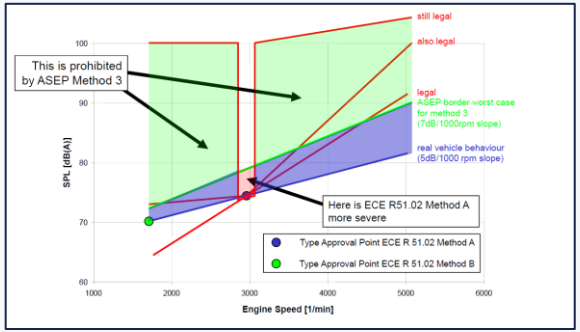
UN R51.02	UN R51.03
Test speed approx. 50 km/h (AA‘) (or 75% Vmax)	Test speed approx. 35 km/h (BB’)
Tested unladen without trailer	Tested with extra load of 50 kg per kW Pn (only N2 and N3)
Test engine speed above S (rated engine speed) (at BB‘)	Test engine speed 85% to 89% of S (at BB’) (M3 and N3) 70% to 74% of S (M2 and N2)
Test gear only first gear that reaches S (dependent on x/n) (MT)	One or two test gears (fulfilling the requirements for driving speed and engine speed)
Maximum result of measurements per vehicle side	Averaging of measurement results per vehicle side (also per gear)
Correction of result by -1 dB(A) and round off (down)	Mathematically rounded to the nearest integer and no correction

- For heavy commercials R51.02 type approval results are lower than R51.03 due to the extra loading
- R51.03 changes are aiming for a better representation of vehicle behavior in real traffic conditions

Representativeness of type approval values for real traffic situations



Source: OICA GRB 32 (2000) (modified for simplicity)



Source: GRB Informal Group ASEP 13.1 (2008)

Category M1 – passenger cars

- R51.03 TA points better aligned to typical urban driving conditions – covering a significant part of realistic operating conditions/accelerations
- R51.02 only covering a very small engine speed range (no off-cycle critera) – risk for uncontrolled behavior outside of test area
- R51.03 is more restrictive due to ASEP by covering a wider operation range – resulting in a vehicle sound better aligned to driving dynamic (acceleration)
- Future UN R51.04 (RD-ASEP) is aiming to further to control the sound behavior much stricter and to define tighter tolerances

- Adapted type approval procedure allows fair guess of vehicle sound emission in real traffic
- Valid even outside urban areas by considering tyre rolling sound curves

Representativeness of type approval values for real traffic situations

	UN R51.02	UN R51.03 ASEP	UN R51.03 & GRB68-03	UN R51.04 RD-ASEP
Covered Gears	MAX2 GEARS	UP TO GEAR i	ALL	ALL
Covered Modes	DEFAULT ONLY	ALL	ALL	ALL
Speed Range	50 km/h to 61 km/h	20 km/h to 80 km/h	10 km/h to 100 km/h	> 0 km/h to 100 km/h
Full load	YES	YES	YES	YES
Part Load	NO	NO	YES	YES
Cruise	NO	ONLY 50 km/h	YES	YES
Covered Environment Condition	UNCLEAR	URBAN + HIGH REV	URBAN + SUBURBAN + HIGH REV	REAL DRIVING W/O HIGHWAY
Model Precision	N.A.	FAIR	FAIR; ext AREA LOOSE	PRECISE
Tolerances	N.A.	2 dB(A) + (Limit - Lurban)	2 dB(A) + (Limit - Lurban) extended area + 6 dB(A)	t.b.d.
Backfire	NOT REGULATED	WITH SUPPLEMENT 3	YES	YES
Sound Enhancement	NOT REGULATED	WITH SUPPLEMENT 3	YES	YES
"Grey Areas"	HIGH	RESTRICTED	VERY RESTRICTED	VERY LIMITED

Source: OICA TF-VS (2021)

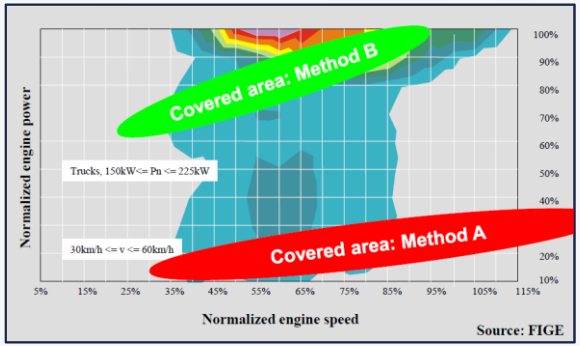
Status 2022

Category M1 – passenger cars

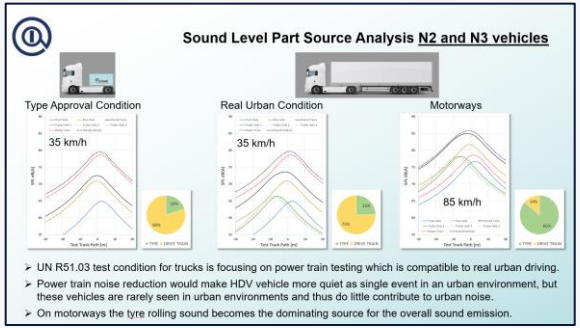
- Development of UN R51 to ensure the sound emission of a vehicle being in line with the type approval value
- Real world scenarios are covered appropriately

➢ Regulation on the best way to be as representative as possible

Representativeness of type approval values for real traffic situations



Source: OICA GRB 33-17 (2011)



Source: OICA TF-VS (2021)

Category N3 – heavy duty trucks

- Adding some test weight, R51.03 type approval points are better aligned to typical urban driving conditions
- Medium engine speed range and high loads are representative for urban and suburban driving (especially with trailer in reality)
- Type approval testing according to R51.03 is still performed without a trailer to strongly focus on PTR sound emission
- Also to avoid excessive wear of the test track by trailer
- Due to increased rolling sound (where long haul vehicles are driven most time), reduced limits cannot reduce sound levels at higher speeds

- Sound emission at higher driving speeds strongly depends on actual configuration (trailer, body)
- PTR reductions help at urban areas (low speed), but mainly driven on motorways, less benefit is expected by lower limits

Representativeness of type approval values for real traffic situations

Conclusions:

- UN R51.02 only covers a very small and non-representative part of the engine operating map
- UN R51.03 rates the vehicles according to their performance - within the real driving conditions map
- Off cycle provisions such as ASEP do not exist in UN R51.02
- By means of border curves, ASEP under UN R51.03 allows to consider a "worst case" behaviour for each vehicle
- Vehicles with “variable sound technology” must follow in a reliable way the principles as desired by the regulator
- Reliable prognoses of the vehicle sound for conditions beside TA points are possible with UN R51.03
- Commercial vehicles are tested under UN R51.03 within the typical driving map in terms of engine speed / load

- The estimation of real sound emissions based on UN R51.03 TA data is possible and reliable
- UN R51.03 is well suited to real driving by consideration of cruising conditions and realistic accelerations

Conclusions and recommendations

Conclusions after peer review of EMISIA study

Conclusion regarding benefits and measures

- Both studies conclude that benefits by further limit reductions are highly limited and time delayed
- Benefits of the CBA appear significantly too high according to recalculation with ATEEL tool
- Both studies conclude that a reduction of tyre rolling sound provides the highest benefit
- Powertrain measures only contribute to sound improvements in conjunction with quite road surfaces and / or tyres
- Improvements by alternative measure such as quiet asphalt or vehicle speed limits evaluated by ATEEL as most efficient

Conclusion regarding results and final limit value proposals

- EMISIA study final proposal provides only minor space for limit reductions –> only a minor improvement can be expected
- The final proposal for category N3 is not considered realistic (see presentations GRB-51-13, GRB-51-20, GRB-53-17)
- Considering higher accelerations is a step back towards UN R51.02 – inefficient and not representative for real traffic
- Most single events, caused by bad driving style or manipulated vehicles, could be handled efficient by traffic monitoring

Recommendations for next Steps

Legislation side – limit value adaptations beyond phase 3

- Waiting for new exhaust emission legislation impact on vehicle design
- Wait for phase 3 vehicles to enter the market and observe the impact on sound level
- Examine more closely costs and risks/drawbacks of other disciplines such as safety and pollutants
- Take also into account the desired/efficient movement of goods and people. e.g. payload or packaging issues

Additional tasks that could help to get a better understanding on real traffic issues

- More campaigns similar to recent studies (Fauville, Bruitparif, G+P Switzerland and FEDRO) help to understand real traffic noise
- Gathering of N3 vehicle data with realistic configuration especially on street types with higher driving speeds

technology experts

Thank you for your attention!

In case of questions or comments,
please do not hesitate to contact us

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