中国汽车技术研究中心有限公司
China Automotive Technology and Research Center Co., Ltd.

Measurement Methods for Noise Emitted by Light-duty Vehicles in Multiple Driving Mode Conditions

-Historical Background, Current Development and Future Topics-

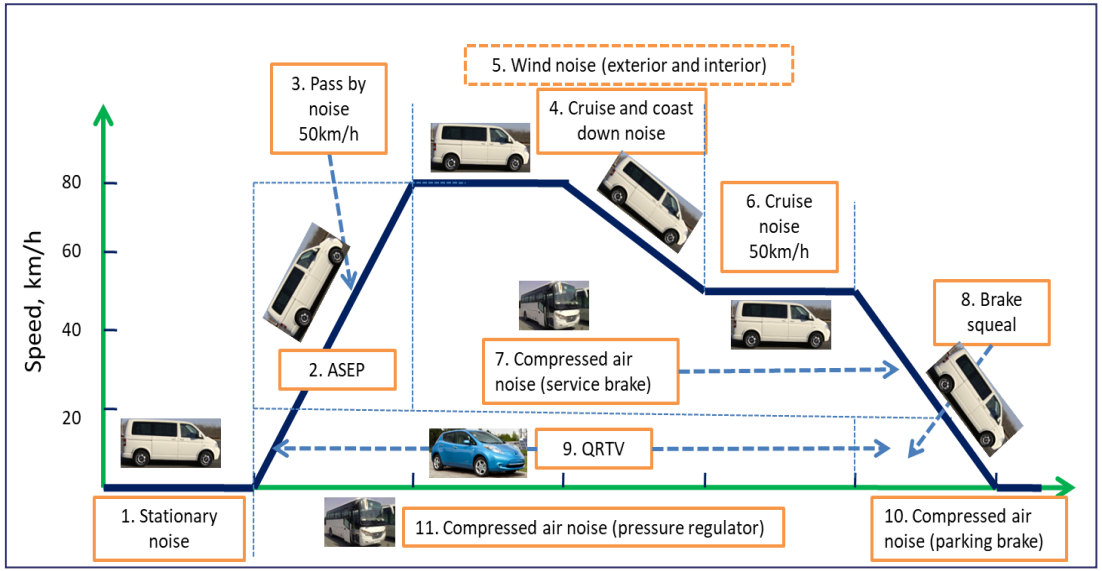
16th ASEP IWG
Conference call on 4th-5th June, 2020.

Dongming Xie

Contents

- The Origin of the Test Methods
- Background Knowledge
- Briefing of the Test Methods
- Comparison with ASEP Test Method
- Relevant Research Topics
- Technical Route and Conclusions
- References and Acknowledgement

The Origin of Test Methods Standard



- China released plans and a long-term technology roadmap for vehicle noise standards and regulations during the 62th session of WP.29 GRB in 2015.
- In the roadmap, it is realized that a noise regulation system to cover all typical behaviors of all vehicles on road will be the top priority of China.
- During the recent 5 years, all 11 items in the left Fig. have been covered or planned by 5 standards projects in China noise standards system .

●National Standard of China GB/T <Measurement Methods for Noise Emitted by Light-duty Vehicles in Multiple Driving Mode Conditions>

- The test methods standard project launched in 2018 and is now waiting for the technical review after comments.
- It is expected for corresponding to the test methods of UN Regulation No.51-03 ASEP.
- The use of China Automotive Test Cycle (corresponding to WLTP) makes it possible for a refined and accurate design.

Background Knowledge

- **From GRB(P) and ASEP**

  - The discussion for creating current Method B (Documents from Netherlands and OICA)

  - Assessments of UN Regulation No. 51-03 (Venoliva Study)

  - ISO system (Annex A of ISO 362-1: 2007, from test cycles to test methods)

  - ASEP system (Documents from previous ASEP IWG)

- **From Ecology and Environment Fields**

  - Environmental quality standards for noise (Noise functional areas of China, Japan and WHO Europe)

  - Complexity of traffic noise (functional areas planning, noise sources and transfer paths)

  - Complexity of vehicle noise (Noise sources, and real driving conditions)

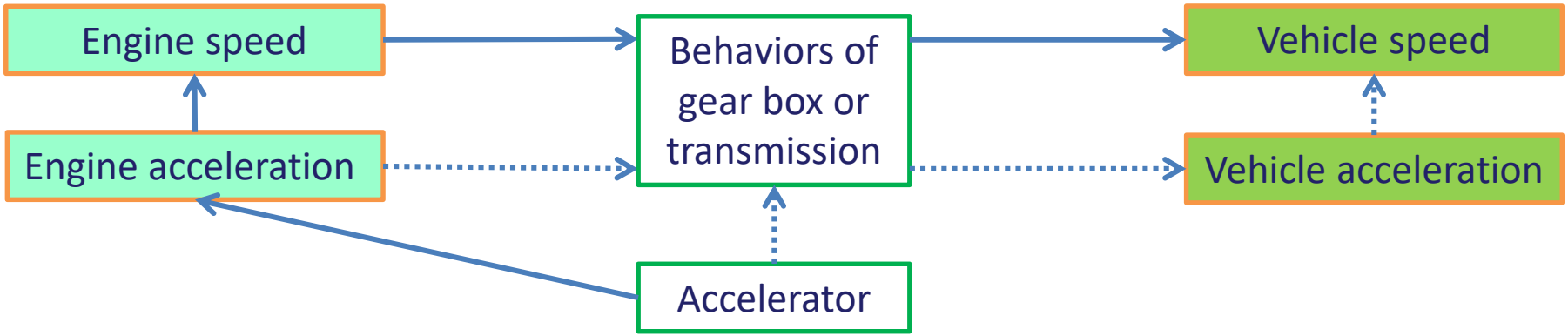
- **Opinions and technologies for designing the test methods are derived from historical researches of GRB(P), ASEP, ISO, China and actual environmental status.**

Key Parameters for Tests

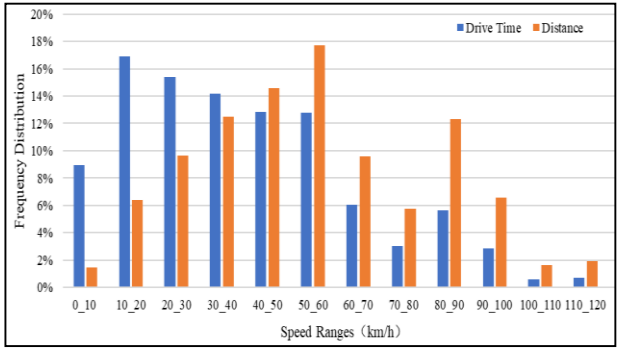
- **Key parameters for test methods**

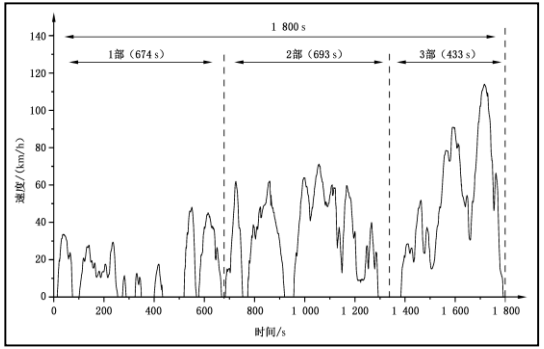
  - Vehicle Speed
  - Engine Speed
  - Vehicle Acceleration
  - Engine Acceleration

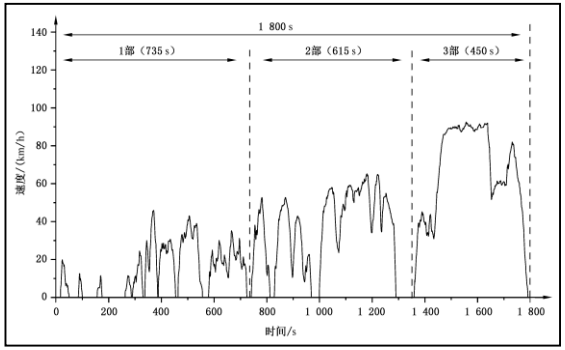
- **Vehicle speed ” is the most sensitive parameters for environmental noise.**
  - ① Set realistic and representative speeds;
  - ② Use reasonable gear @ speed for realistic engine speed;
  - ③ Control the accelerator properly @ speed for reproduced.



Realistic and Sensitive Speeds

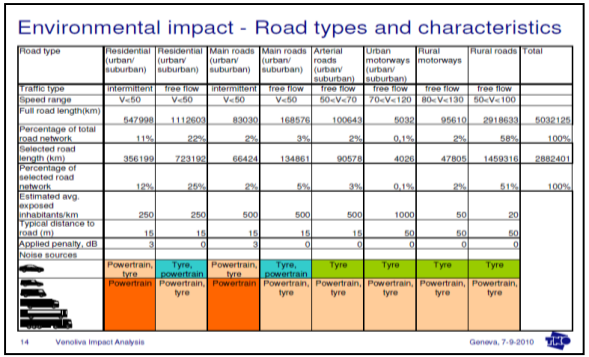






- **30km/h, 50km/h and 70km/h for acceleration noise, 80km/h and 110 (90) km/h for cruise noise.**

Drive Time Distribution (%)	0~70km/h	>70km/h	>75km/h	>80km/h
Acceleration	34.80%	18.99%	16.72%	12.45%
Deceleration	33.40%	18.72%	16.40%	13.92%
Cruise	31.80%	62.29%	66.88%	73.63%



Choose Reasonable Gears

- **The increasing gear numbers are expected for covering frequent speed distribution better.**

Test speeds		30km/h	50km/h	70km/h	≥80km/h
Formulas for Test Gears		(1+X/2)/2+1	(1+X/2)	(X+X/2)/2+1	----
		Calculated Test Gears for lockable gear boxes*			
Total gears	4	2	3	4	Highest lockable gear
	5	2	3	4	
	6	3	4	5	
	7	3	4	6	
	8	3	5	7	
	9	3	5	7	
	10	4	6	8	
* Round down if the result is not an integer.					

Principle for lockable gears:

A. Try to use the calculated gears shown above, but if cannot, it is permitted to make measurement as per the adjacent gear recommended by manufacturers.

Principal for non-lockable gears:

A. For non-lockable automatic transmission, adaptive transmission or CVT, it is allowed to use additional electronic or mechanical devices to fix the gear ratios.

B. If A is unsatisfied, use Gear position D and try to avoid gear shifting to a gear ratio which is not used in urban traffic at least.

Control the Accelerator Properly

How to use accelerator:

- When test vehicle enters line AA’ or pre-acceleration position point before line AA ’, quickly depress acceleration pedal to **appropriate position (POT or WOT)** and keep the pedal at the position **stably**;
- Release the accelerator until the rearmost part of test vehicle passes line BB'.

How to calculate the acceleration:

- Record $v_{AA'}$, $v_{PP'}$ and $v_{BB'}$ and perform test acceleration calculation;
- Acceleration formulas are the same as UN Regulation No. 51-03.

What’s the target acceleration:

Test Speeds	30km/h	50km/h	70km/h	≥80km/h
Accelerator Position	POT or WOT (Both are possible)			POT (Cruise)
Acceleration (m/s^2)	$0.5 \le a_{test} \le 3.5$	$0.5 \le a_{test} \le 3.0$	$0.3 \le a_{test} \le 2.5$	$a_{test} \le 0.15$

- The wide range of acceleration is for purpose of covering different vehicle performance.

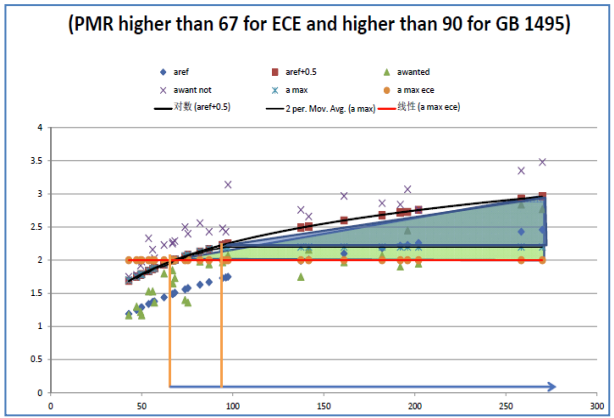
Scope, Sub-categories and Summary

Full scope:

- M_1, N_1, M_2(GVM ≤3 500kg)

Sub-categories:

- M_1(PMR＜90kw/t): 2 runs @ 30km/h, 50km/h, 70km/h, 80km/h, 110km/h;
  - ※ Thereinto, Multi-purpose Van: 2 runs @ 30km/h, 50km/h, 70km/h, 80km/h, 90km/h.
- M_1(PMR≥90kw/t): 2-4 runs @ 30km/h, 50km/h, 70km/h; and 2 runs @ 80km/h, 110km/h.
- N_1 and M_2 (GVM ≤3 500kg): 2 runs @ 30km/h, 50km/h, 70km/h; and 2 runs @ 80km/h, 90km/h.



Test speeds (km/h)	$V_{PP'}$=30±1	$V_{PP'}$=50±1	$V_{PP'}$=70±2
Engine speeds (r/min)	$n_{BB'}$=Idle to 80%S		
Acceleration (m/s²)	$0.5 \le a_{test} \le 3.5$	$0.5 \le a_{test} \le 3.0$	$0.3 \le a_{test} \le 2.5$
Test Gears	(1+X/2)/2+1	(1+X/2)	(X+X/2)/2+1
	D for unlockable		
Accelerator Position	POT or WOT (Both are possible)		
Noise Tested	L_{max} per run for left side and right side separately		
No. of Runs*	2	2	2
Intermediate Result	Average of per side	Average of per side	Average of per side
Final result	Higher of averages	Higher of averages	Higher of averages
*M_1 (PMR≥90 kW/t), 2 runs can add at different acceleration.			

Test speeds (km/h)	$V_{PP'}$=80±2	$V_{PP'}$=110±2 for M_1 $V_{PP'}$=90±2 for others
Engine speeds (r/min)	$n_{BB'}$=Idle to 80%S	
Acceleration (m/s²)	$a_{test} \le 0.15$	
Test Gears	Highest lockable gear or D for unlockable	
Accelerator Position	POT (Cruise)	
Noise Tested (dB(A))	L_{max} per run for left side and right side separately	
No. of Runs	2	2
Intermediate Result	Average of per side	Average of per side
Final result	Higher of averages	Higher of averages

Comparison with ASEP Test Method

Items		GB/T (Draft)	UN ASEP (Draft)
Control Ranges	Speed	20-110 km/h (30, 50, 70, 80, 90, 110km/h)	0-100 km/h (Any, not fixed)
	Engine speed	Idle to 80% S	Idle to 80% S
	Acceleration	0-3.5 m/s^2 (corresponding to speed)	0-4.0 m/s^2
	Performance	0-48.6 m^2/s^3 (corresponding to speed)	0-35.0 m^2/s^3
	Gear	Recommended gears (corresponding to speed)	Any
	Mode	Any	Any
No. of Runs		10 or 16	[15]
Intermediate Result		Average of per side	----
Final result		Higher of averages	[Higher of per side]

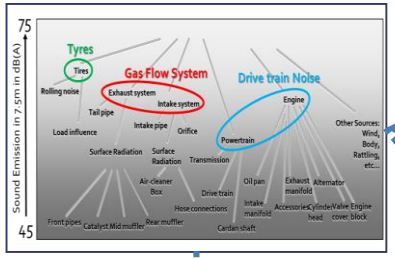
The differences between GB/T (Draft) and UN ASEP (Draft) :

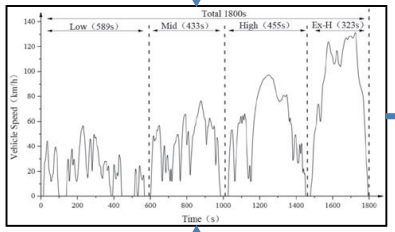
- GB/T tests at fixed speeds, and builds up ranges for other parameters based on different speed conditions;
- UN ASEP sets general ranges for all parameters, and tests randomly.

Relevant Research Topics

- **Assessment system**
  - The potential to combine the test methods with the Statistical Sound Expectation Model.
  - The potential to enrich and simplify the current Regulation or standard system.
- **More vehicle categories**
  - How is the typical noise pollution, noise sources and test cycles for Heavy-duty vehicles?
  - How to design more simplified, accurate and effective test methods for different sub-categories.
- **Other noise caused by vehicles**
  - How is the burst noise, the low frequency noise and delivery noise, and how to test properly?
- **Systematic consideration**
  - What is the exact role and the target of the current test methods inside the general system?
  - The ethical issues of setting control ranges.
  - Further more, how the control ranges clear and definite social responsibilities of different participants, and how a new system will match with the new situations?

Technical Roadmap and Conclusions





Test Methods

Limit Values

- Noise sources, test cycles and noise issues are the three key source powers for creating the test methods. More studies are needed for the correlations.
- The big data from environmental noise monitoring and test cycle studying makes the previous technical route for test methods more possible, more accurate and it should be proved effective.
- The development of ASEP Sound Model are releasing more space for the creation of test methods and assessments.

Reference and Acknowledgement

• Gerhard, H.M.: Presentation on Noise test Results of vehicles measurement according to the current ISO 362 test. WP.29 GRB Thirty-sixth Session, Geneva, 26-28 February 2002.

• De Graaff, E.: Presentation on the ACEA method, limit values and the demands on noise sources. WP.29 GRB Thirty-sixth Session, Geneva, 26-28 February 2002.

• ISO: ISO 362-1: 2007. Measurement of Noise Emitted by Accelerating Road Vehicles — Engineering Method — Part 1: M and N Categories. Geneva, 2007.

• Dittrich, M.: Impact assessment of the policy options Venoliva Study. WP.29 GRB Fifty-second Session, Geneva, 6-8 September 2010.

• China: Plans for China vehicle noise standards working group. WP.29 GRB Sixty-second Session, Geneva, 1-3 September 2015.

• Gerhard, H.M.: Traffic Noise Emission of Light Duty Vehicles Sound Sources and Influence Factors. 2017 International Conference on Automotive NVH Control Technology of SAE-China, Nanjing, 02 May 2017.

• China: ASEP SCOPE and Border. ASEP 5th Session, Tokyo, 7-9 November 2017.

• Liu, Y.: Feasibility Study of Using WLTC for Fuel Consumption Certification of Chinese Light-Duty Vehicles. SAE International, 03 April 2018.

• National Standard of China: GB/T 38146.1-2019 China automotive test cycle – Part 1: Light-duty vehicles (2019).

• Swiss Confederation: Maps of Switzerland. https://map.geo.admin.ch (2020).

Thanks for your attention

Web site： www.catarc.org.cn