Research on Measurement Methods for HDV in Multiple Driving Mode Conditions

- CATC Data Study and Measurement Methods Research -

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Review

- June, 2020, China introduced “Measurement Methods for Noise Emitted by Light-duty Vehicles in Multiple Driving Mode Conditions” in the 16th ASEP IWG meeting.
- August, 2021, the project GB/T “Measurement Methods for Noise Emitted by Heavy-duty Vehicles in Multiple Driving Mode Conditions” launched.
- October, 2021, GB/T 40578-2021 “Measurement Methods for Noise Emitted by Light-duty Vehicles in Multiple Driving Mode Conditions” published.
- September, 2022, HDV working condition survey conducted for the measurement methods based on CATC data.
- January, 2023, GB/T “Measurement Methods for Noise Emitted by Heavy-duty Vehicles in Multiple Driving Mode Conditions” began soliciting public opinion.

GB/T 40578-2021 for LDV

Acceleration noise

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/s^2)	$0.5 \le a_{test} \le 3.5$	$0.5 \le a_{test} \le 3.0$	$0.3 \le a_{test} \le 2.5$
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		
Intermediate Result	Average of per side		
Final result	Higher one of averages		
*M_1 (PMR≥90 kW/t), 2 runs can be added at different acceleration.			

Cruise noise

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/s^2)	$a_{test} \le 0.15$	
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	
Intermediate Result	Average of per side	
Final result	Higher one of averages	

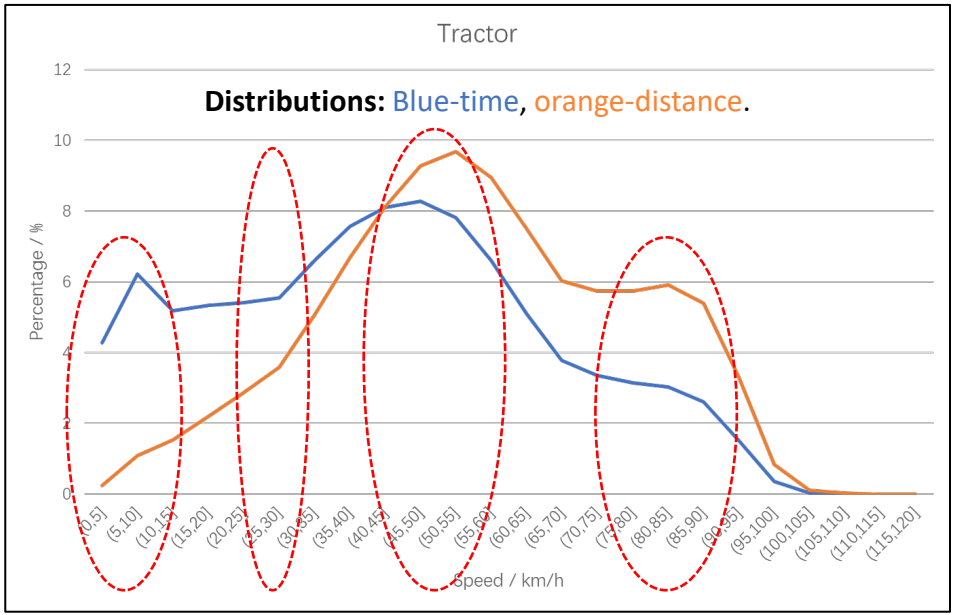
Data Survey for HDV

- **Established a fleet composed of 76 heavy-duty vehicles, covering typical vehicle types, vocations and cities all over China.**
- **Collected 1hz real-time data including vehicle speed, engine speed and other parameters by free driving operation.**
- **Collected about 1.5 million kilometers' real-road data by 3-6 months of stable driving.**

	Bus	Coach	Heavy Truck	Light Truck	Dumper	Tractor
Fleet Size	13	12	15	12	10	14
Distance (10000 km)	43.74	28.14	23.22	13.23	13.46	29.63
City	16 cities					
Vocation	Intercity Long Haul, Local Delivery, City Construction, Passenger Transportion…					

- **Based on collected data, determine typical scenes that are prone to generate noise. Establish corresponding test projects in the standard system.**
- **Based on scene information, calculate statistical characteristics to design specific test methods and conditions.**

Data Survey for HDV (Speed & Engine Speed)



Engine Speed (Rated：1900rpm）					
Percentile（Time）	50%	80%	90%	95%	99%
50	1142	1300	1355	1397	1470
Percentage	60.1%	68.4%	71.3%	73.5%	77.4%
80	1519	1575	1615	1637	1683
Percent	79.9%	82.9%	85.0%	86.2%	88.6%
Acceleration Percentile(m/s2)					
50	0.14	0.25	0.33	0.42	0.61
80	0.08	0.14	0.19	0.25	0.44

- The test methods here are quite different from current test methods.
- The methods are designed firstly by speed range and then other parameters are considered.

GB/T “Measurement Methods for Noise Emitted by Heavy-duty Vehicles in Multiple Driving Mode Conditions”

Vehicle Type	Testing Driving Mode Conditions			
	Starting	Low-Speed Acceleration	Mid-Speed Cruise	High-Speed Cruise
Tractor	√	√	√	√
Dumper	√	√	√	——
Truck	√	√	√	√
Bus	√	√	√	——
Coach	√	√	√	√

1. Dumpers and Buses do not take the High-Speed Cruise test.
2. “√”: the test is required， “——” the test is not required.

GB/T "Measurement Methods for Noise Emitted by Heavy-duty Vehicles in Multiple Driving Mode Conditions"

Starting condition test L_{start}	Start the vehicle, wait for the engine speed or power system to stabilize, measure the maximum "A" weighted sound pressure level (Unloading sudden noise of compressed air system is not included).
Low-speed acceleration test $L_{low\ acc}$	v_{test}: 30 km/h ±2km/h, n_{test}≤90%S Gear selection (if possible): can be accelerated steadily, within the v_{test} range and n_{test} range, n_{test} as high as possible.
Mid-Speed Cruise test $L_{med\ cru}$	v_{test}: 50 km/h ±2km/h, n_{test}≤80%S* Gear selection (if possible): can be accelerated steadily, within the v_{test} range and n_{test} range, Gear as high as possible.
High-Speed Cruise test $L_{high\ cru}$	V_{test}: 80 km/h ±2km/h, n_{test}≤80%S* Gear selection (if possible): can be accelerated steadily, within the v_{test} range and n_{test} range, Gear as high as possible.

* If it is limited by the maximum speed, acceleration performance of the test vehicle and measurement site, the test target speed can be adjusted appropriately and noted in the test report.

GB/T “Measurement Methods for Noise Emitted by Heavy-duty Vehicles in Multiple Driving Mode Conditions”

Vehicle Type		Weighting coefficient k_i*			
		Starting weighting coefficient k_{start}	Low speed acceleration weighting coefficient $k_{low\ acc}$	Mid-speed cruise weighting coefficient $k_{med\ cru}$	High-speed cruise weighting coefficient $k_{high\ cru}$
Speed Range (km/h)		0-10	10-35	35-60	60+
Tractor		18.2%	20.3%	14.9%	46.6%
Dumper		36.2%	34.6%	29.2%	--
Truck	（GVW≤5 500 kg）	26.3%	29.7%	23.3%	20.7%
	（GVW＞5 500 kg）	26.6%	26.7%	26.8%	19.9%
Bus		44.9%	44.0%	11.1%	--
Coach		28.8%	21.0%	22.0%	28.2%

* Derived from the time accumulation survey results.

GB/T “Measurement Methods for Noise Emitted by Heavy-duty Vehicles in Multiple Driving Mode Conditions”

$$L_{\text{mul mod}}=10\cdot\lg\left[\sum_{i=1}^{4} k_i\cdot 10^{(0.1Li)}\right]$$

i : driving mode conditions number（i =1, 2, 3, 4）

k_i : weighting factors k_{start}, $k_{\text{low acc}}$, $k_{\text{med cru}}$, $k_{\text{high cru}}$

L_i: noise result L_{start} , $L_{\text{low acc}}$, $L_{\text{med cru}}$, $L_{\text{high cru}}$

Conclusions

- GB/T “Measurement Methods for Noise Emitted by Heavy-duty Vehicles in Multiple Driving Mode Conditions” is soliciting public opinion.
- 30 km/h±2km/h, 50 km/h±2km/h, 80 km/h±2km/h are three typical speed ranges.
- Starting, low-speed acceleration, mid-speed cruise, high-speed cruise testing are with different target vehicle speed, engine speed and gears.
- A consolidate noise result was calculated according to the time accumulation, reflecting the real influence of HDVs.

Thanks for your attention!