

Countermeasures for Pass-by Noise Limit in R51-03 Phase3

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R51-03, which is the regulation for pass-by noise, has been in effect since 2016. The noise limit was tightened about 2dB in each phase and R51-03 phase3 was initially assumed to be difficult to comply with easily. However vehicles that comply with phase3 are now being introduced to the market. This paper shows how to meet the noise limit in R51-03 phase3 from the perspective of not only the vehicle side but also the regulation aspect.

The final noise level must be reduced by about 2 dB in order to meet the phase3 noise limit from phase2 value. The final noise is determined through the constant speed test and the wide open throttle test, so the required reduction target for each test method was defined as a guideline. Sound source contribution analysis was performed for each vehicle, and appropriate targets for each vehicle were defined and developed as necessary.

Countermeasures for tyre noise at constant speed are shown in Table 1. Initially, the relationship between tyre noise reduction and trade-off performance was unclear quantitatively, but it was possible to meet the targets both noise and trade-off performance by creating prototype tyres and installing them on vehicles. Coasting noise target was defined for each tyre width and development was carried out for each vehicle in collaboration with tyre suppliers.

One possible solution would be to surround the engine, which is the source of the noise, with various sound-proofing materials. However, encapsulation would prevent the heat from escaping, causing the temperature of each part to rise significantly, which would be negative impact to cooling performance. Taking cooling performance into account, countermeasures such as sound absorbent material on the engine under cover, sound absorbent material on the floor under cover, and absorbent fender liners were implemented. These countermeasures are effective both acceleration and constant speed.

Countermeasures for noise source, such as adding the resonator to reduce intake noise, increasing muffler capacity to reduce exhaust noise, increasing the rigidity of the engine timing-chain cover, were also implemented.

It is effective to reduce engine speed for noise reduction during acceleration. The power of hybrid vehicle is determined by engine torque, engine speed, and battery assistance. During full-load driving, an operating line that increases power performance is used, while during partial-load driving, an operating line that reduces fuel consumption is used. In the R51-03 acceleration driving test method, partial-load driving is allowed if the acceleration and engine speed are higher than actual urban driving situation. With improvements in battery performance, it has become possible to reduce engine speed by using battery assistance while minimizing trade-off effects such as fuel consumption and battery load. (Fig.1).

The regulation was also revised. There are various measurement uncertainties during the test. The largest uncertainties are temperature and road surface and regulation was revised to allow the correction both of them. And maximum engine speed during the test was changed from S to N_{MAX} in order to fit the actual urban driving situation. These regulatory amendments entered into force as R51-03 Supplement7 from January in 2023 before the phase3 limit was introduced from July in 2024. There is a movement to revise the current Additional Sound Emission Provisions (ASEP), which only specifies full-load driving, to RD-ASEP, which also specifies partial-load driving, and to update it to R51-04.

Table1 Countermeasures for tyre noise at constant speed

Position	Mechanism	Frequency	Countermeasures
Tyre groove	Main groove resonance	800~1.25kHz	Shallow groove
	Pattern pitch noise	800~1.25kHz	Pattern change
Tyre Structure	Tread vibration	500~1kHz	Stiffness down of circumferential direction
	Sidewall vibration	500~1kHz	Gauge up of local side wall
Grounded surface	Road impact	500~1kHz	Stiffness down of tread compression
	Horn effect	Every frequency	Narrow tread Small rectangle ratio

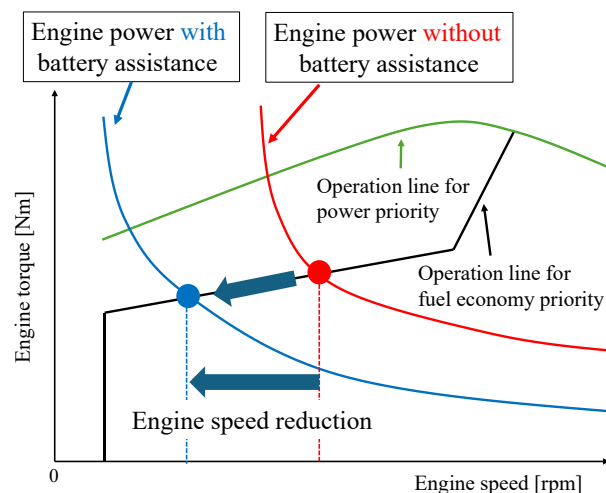


Fig.1 Engine speed reduction (Image)