

DRIVING PATTERNS IN JAPAN AND THEIR RELATIONS TO PASS-BY NOISE TESTING METHODS

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1. INTRODUCTION

To reduce actual traffic noise more effectively to improve noise environment of resident, the testing methods of vehicle pass-by noise based on ISO362 has been focused to re-examine in their relations to actual urban traffic noise.

The ISO/TC43/SC1/WG42, started in 1993, has been discussing on an appropriate future testing methods.

The counterpart of ISO WG42 in Japan, JSAE(Society of Automotive Engineers in Japan), started the investigation of representative urban driving patterns in Japan since 1995.

This paper describes the results of initial investigation, including derived representative urban driving modes for passenger cars and heavy trucks, correlation of test results between these modes and ISO362 results, and major arguments for current ISO362 method.

2. PURPOSE AND FLOW OF THIS STUDY

Based on the investigation results of driving patterns, the urban driving modes ("Urban modes") are derived for both passenger cars and heavy trucks. These modes are aimed to extract 95 percentile noise level in urban driving conditions from the data of time frequency of engine nearfield noise due to engine speed and torque, and time frequency of noise levels due to driving conditions. The test results on these derived test conditions ("Urban modes") are then compared with those on ISO362 method, and correlation of these results are discussed. Fig. 1 shows the flow diagram of this study.

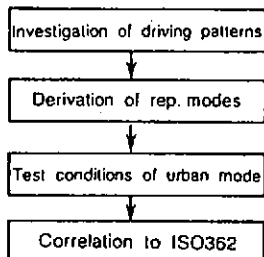


Fig.1 Flow of the study

3. INVESTIGATION OF URBAN DRIVING PATTERNS

The investigation of driving patterns for passenger car (unladen) and heavy truck (1G-laden) are conducted in the example of inner-city road (Tsukuba city) and inter-city road (national trunk road No.6). Test vehicles, tested routes and measured quantities is shown in Table-1, and examples of time frequency distribution results are shown in Fig. 2 and 3.

The vehicle speeds and accelerations are very similar in two categories, however throttle conditions for heavy trucks show significantly wide distribution including similar condition to ISO362(WOT), while these for passenger car are less than 20 %, and engine speeds are distributed less than 1/2S that means completely differed from ISO test conditions.

Table. 1 Driving patterns investigation

Test vehicles: 1) Passenger car(M1) 2000 cc
2) Heavy truck(N3) 15800 cc GVW 19.65t
Test routes: 1) Tsukuba city (inner-city road)
2) National trunk road 6 (inter-city road)
Measured quantities : 1) Vehicle speed 2) Engine speed
3) Throttle opening 4) Engine noise

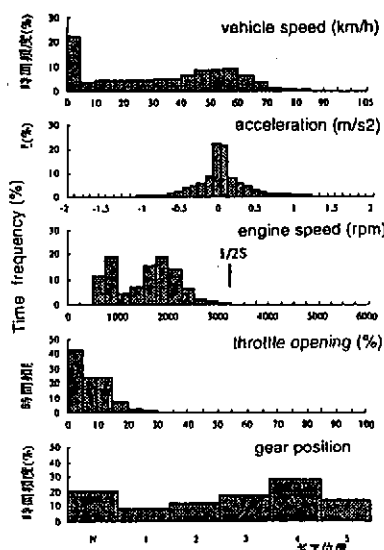


Fig.2. Time frequency distribution (Passenger car)

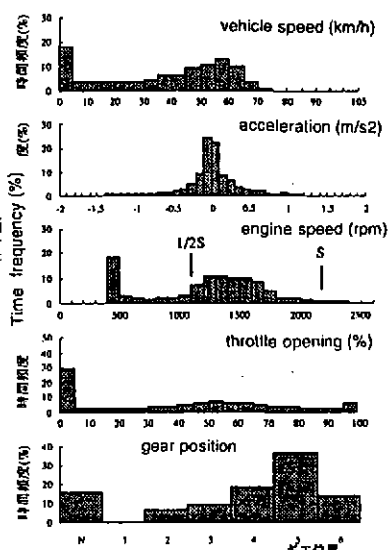


Fig.3. Time frequency distribution (Heavy duty truck)

4. DERIVATION OF REPRESENTATIVE MODES

FLOW OF REPRESENTATIVE MODES DERIVATION

The representative modes of urban driving conditions are derived from the investigation results of inner-city and inter-city roads. These modes are representing high contribution modes of noise energy within whole noise energy during urban driving considering time frequency and noise energy frequency as shown in Fig. 4.

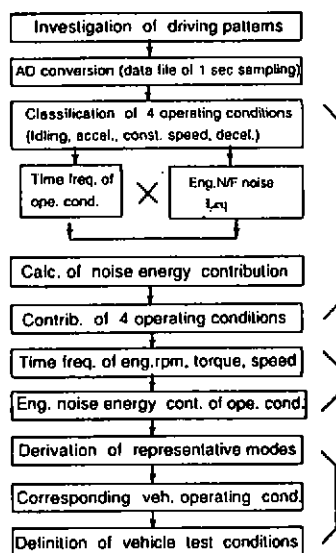


Fig. 4 Flow chart of derivation of urban representative modes

CONTRIBUTION ANALYSIS OF EACH DRIVING PATTERN

The classified results of whole urban driving data to each driving pattern (acceleration, constant speed, deceleration and idling) are shown in Table 2.

From the results of time frequency, the percentage of acceleration is not high and constant speed shows high percentage, while in case of noise energy contribution which calculated from engine near field noise shows higher contribution of acceleration, and sum of acceleration and constant speed dominates over 90 % of energy regardless to roads.

Table 2 Contribution of each driving pattern

		(Threshold of acceleration : 0.30m/s ²)				Eng. nearfield noise LeqdB(A)					Noise energy cont. (%)			
Test Vehicle	Routes	Time percentage (%)				Idle	Acc.	Con.	Dec.	Total	Idle	Acc.	Con.	Dec.
Pass.	Nat. route 6	20.47	17.46	44.62	17.44	76.14	91.20	89.20	86.23	88.35	1.23	33.77	54.29	10.72
Car	Tsukuba C.	17.81	19.45	43.22	20.61	75.52	92.75	90.22	86.62	89.64	0.69	39.84	49.32	10.31
Heavy	Nat. route 6	12.56	17.24	55.93	14.26	84.31	103.26	100.30	97.30	100.19	0.33	34.96	57.36	7.35
Truck	Tsukuba C.	17.69	14.39	55.75	12.18	84.43	101.55	99.71	95.87	98.57	0.76	38.49	64.21	6.42

EXTRACTION OF ENGINE OPERATING CONDITIONS

Fig. 5 and 6 show the noise energy distribution (contour) and engine operating conditions during acceleration.

Similar to the results of time frequency analysis, operating conditions for passenger car exist less than $1/2$ S and low throttle opening, while those for heavy trucks more than $1/2$ S and very high throttle opening very close to WOT.

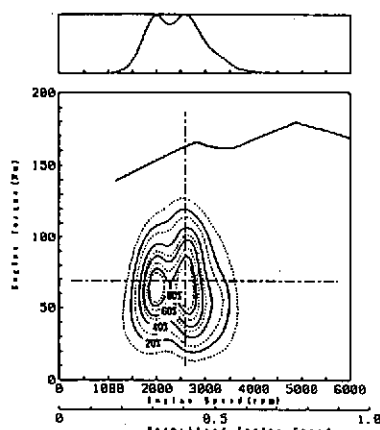


Fig. 5. Contribution contour of engine nearfield noise (Passenger car)

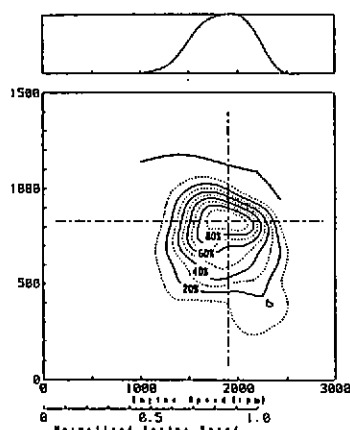


Fig. 6. Contribution contour of engine nearfield noise (Heavy duty truck)

DEFINITION OF TEST CONDITIONS ("URBAN MODES")

Table 3 shows the resultant test conditions derived from acceleration and constant speed driving which dominate more than 90 % noise energy of total altogether.

For acceleration test, vehicle speed and acceleration conditions are selected at most frequent gear position that correspond to engine speed and engine torque derived from Fig. 5 and 6.

The magnitudes of acceleration are similar for both categories, while throttle conditions are significantly different between two categories. For constant speed test, the most frequent vehicle speeds and gear position in urban driving are selected.

Table 3 "Urban modes" (Representing modes of urban driving patterns)

		Rep. modes		Test cond. of Urban Mode		
		Eng. sp. $\frac{1}{2}$ (rpm)	Eng. Trq. (Nm)	Gear Pos. ¹	Veh. Sp. $\frac{1}{2}$ (km/h)	Veh. Acc. $\frac{1}{2}$ (m/s ²)
Pass. Car	Acc.	2600	69	3	53.1	0.55 (18.3%)
	Con.	2000	—	3	60.0	—
Heavy Truck	Acc.	1900	833	4	46.8	0.59 (93.8%)
	Con.	1600	—	3	60.0	—

5. COMPARISON OF URBAN MODES AND ISO362 RESULTS TEST VEHICLES AND CONDITIONS

The pass-by noise tests are conducted with 4 passenger cars and 2 heavy trucks for both "urban mode" and ISO362 method.

Table 4 shows test vehicles and specifications of tires.

Microphone position and test track configuration are identical to ISO conditions for "Urban Modes" test.

Table 4 Test vehicle specification

Pass.car A:	1300cc	185/55R14
Pass.car B:	2000cc	205/55R15
Pass.car C:	2000cc	195/65R15
Pass.car D:	2500cc	205/55R16
Heavy truck E:	11R22.5	GVW 19.8t
Heavy truck F:	11R22.5	GVW 19.8t

NOISE LEVEL COMPARISON BETWEEN TWO METHODS

Fig.7 shows the results of pass-by noise levels(range) for both methods. The results are very close in case of heavy trucks, while ISO results are far higher in case of passenger cars as anticipated.

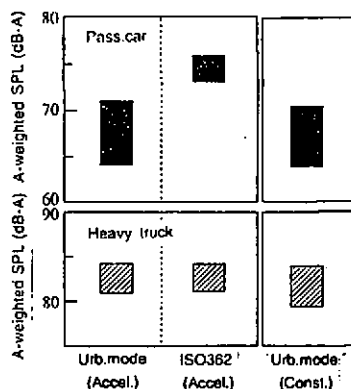


Fig. 7 Noise level comparison of two modes

CORRELATION BETWEEN "URBAN MODES" AND ISO362

Fig. 8 shows the correlation between 2 methods.

The correlation coefficient is 0.974, very high, in case of heavy trucks, while 0.307, almost no correlation, in case of passenger cars.

EFFECTS ON TYRE/ROAD NOISE DUE TO TEST METHODS

Fig. 9 shows the pass-by noise level differences between standard tyres and smooth tyres due to both test methods.

The reduction effects due to smooth tyres are underestimated in case of ISO362 compared with "Urban modes" results for passenger cars.

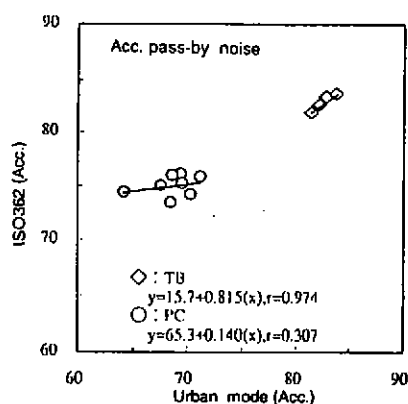


Fig. 8 Correlation between two modes

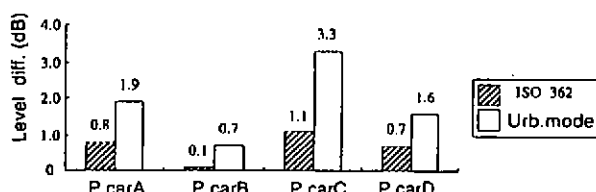


Fig. 9 Acceleration pass-by noise differences between standard tyres and smooth tyres (passenger cars)

6. CONCLUSION

INVESTIGATION OF URBAN DRIVING PATTERNS

The test modes representing urban driving ("Urban modes") are derived from time frequency data of vehicle speed, engine torque, and energy contribution of engine noise.

As the operation conditions, acceleration and constant speed occupy more than 90 % of time frequency distribution, and the magnitudes of acceleration are similar regardless of the categories.

Throttle opening is very close to WOT in case of heavy trucks, while is very low (less than 20%) in case of passenger cars.

These derived test modes ("Urban modes") are equivalent to 95 percentile of cumulative frequency of engine near field noise as aimed.

CORRELATIONS BETWEEN URBAN MODE AND ISO RESULTS

Correlation coefficient of heavy trucks are very high ($r = 0.974$) due to similar throttle conditions between two modes.

Correlation coefficient of passenger cars are very poor ($r = 0.307$) due to significant difference of throttle conditions between two modes.

The reduction effects of tyre / road noise, which assumed to be very effective for the reduction of traffic noise, are tend to be underestimated in the results of ISO362 compared with "Urban modes".

SUMMARY

Therefore it is desirable to develop the new pass-by noise test method which is much closer and more representative to urban driving modes.

7. FUTURE RESEARCH

The mainpoints of problems for current ISO362 method are clarified with this study although limited categories investigation.

We will extend this study to develop the new test method representing urban driving with increasing test vehicle categories, test routes, number of drivers, and loading conditions.

References

- (1) ISO362: 1981 "Acoustics - Measurement of Noise Emitted by Accelerating Road Vehicles - Engineering Method"
- (2) T. Berge, "Vehicle noise emission limits - Influence on traffic noise levels past and future"
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