Motor Cycle Noise in an Australian Context

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ABSTRACT: Traffic noise distributions for different classes of vehicles in a suburban area are compared. Heavy articulated vehicles are the major noise source but motor cycles are also extremely and unjustifiably noisy. All cycles in a small test population were found to comply with Regulations made under the N.S.W. Noise Control Act of 1975 (NCA 1975) but a significant fraction did not comply with Australian Design Rule 28. Correlation between the two measures of noise emission is not good. A further test of average exhaust noise for typical riding behaviour round a test course suggests that NCA 1975 procedures provide a good measure of average noisiness, though this may be underestimated for cycles of small engine capacity. Some further suggestions are made.

1. INTRODUCTION

Of all the forms of noise pollution affecting the community, that due to motor traffic is perhaps the most pervasive and annoying. Certainly airport and railway noise may be more extreme but each of these sources is localized and presents well-defined technical problems, while with motor traffic the sources are widely dispersed and behavioural problems are mixed in with technical ones.

The general problem of motor traffic noise was reviewed in detail not long ago by Delany (1974). It is not our purpose here to try to add substantially to existing knowledge but rather to examine certain problems in an Australian context and to describe the results of preliminary study bearing particularly on the increasing problem of noise from motorcycles.

The noise emission from motor vehicles in Australia is, in principle, limited by the requirements of Australian Design Rules 28 and 28A of 1976 and 1977 (hereafter referred to as ADR28 and ADR28A respectively), and in addition by various State Acts such as the New South Wales Noise Control Act, 1975 and its 1979 Regulations and amendments (hereafter referred to as NCA 1975). Broadly speaking, ADR28 and ADR28A refer to noise emission during an acceleration test under closely specified conditions, while NCA 1975 refers to exhaust noise under stationary conditions with the engine unloaded. Tests under ADR28 and 28A are relatively complicated because of their special site requirements while NCA 1975 tests are designed as simple kerbside checks on suspect vehicles.

It is clearly of interest to know the correlation between ADR28 or 28A and NCA 1975 measurements and the average noise emission from vehicles in use under Australian conditions, and it is also of interest to know to what extent vehicles in everyday use conform to the requirements of each of these sets of regulations. This study is therefore supplementary to the discussion in the preface to Australian Standard AS2240 (1979) which treats the correlations between different noise measurement procedures in more detail.

2. NOISE-LEVEL SURVEY

The measurements specified in ADR28 and ADR28A are designed to specify and limit the maximum noise emission from vehicles in motion. It is therefore of interest to compare the specified limits with the noise emission from vehicles in a typical situation where annoyance is appreciable but not extreme. The measurement site chosen was on the New England Highway where it passes through Armidale, with traffic climbing a moderate grade through a typical open suburban built-up area with little contribution from reflection from buildings and a speed limit of 60 km/h. The relatively light traffic level made the separation of contributions from individual vehicles a simple matter.

For convenience the traffic was classified into only four groups: (a) cars and light vehicles, (b) heavy vehicles, (c) heavy articulated vehicles and (d) motor cycles. The design limits specified in ADR28 for these classes are approximately (a) 84 dB(A), (b) 89 dB(A), (c) 92 dB(A) and (d) 86 dB(A) with these limits being reduced by about 3 dB in ADR28A for vehicles manufactured after about mid 1980. The limits specified for motor cycles are further subdivided according to engine capacity but we shall postpone consideration of this point until later.

Since the ADR tests specify that the measuring microphone be set up 7.5 m from the centre-line of the path of the vehicle in an otherwise clear area, a test site conforming approximately to these requirements was chosen and measurements of maximum noise level were made on every vehicle passing during the measurement period. A subsequent measurement period extended the sample of motor cycles so that the numbers in the four categories were adequate for statistical analysis. The results are shown in Table 1.

TABLE 1
VEHICLE NOISE LEVELS IN dB (A)

Type	Number	ADR 28 limit	Measured mean	Standard Devn.
Cars and Light Vehicles	959	84	70.7	3.1
Heavy Vehicles	118	89	80.0	4.6
Heavy Articulated Vehicles	96	92	87.2	3.3
Motor Cycles	153	86	78.4	4.3

As they stand, these results look reasonably satisfactory in terms of the limits set, though more information can be extracted from the statistical distributions. Initially however we note that heavy articulated vehicles are clearly the major noise sources encountered and that, for their passenger and load-carrying capacity, motor cycles are much nosier than cars and rank closely with general heavy transport vehicles in the non-articulated range.

The histograms in Fig. 1 give the measured results in more detail. As expected, the distributions are more or less normal in shape (on these axes a normal distribution is an inverted parabola) except that the distributions both for cars and other light vehicles, and particularly for motor cycles, have tails extending to quite high noise levels. About 3 per cent of heavy articulated vehicles and nearly 10 per cent of motor cycles exceeded the ADR28 limit at the measuring point. A subjective assessment suggested that in most cases the excessive noise was caused by defective or modified exhaust systems.

3. MOTOR CYCLE NOISE

While heavy and articulated vehicles clearly pose major noise problems, they at least have the justification that they are transporting large loads and are generally confined to highways and industrial environments. Motor cycles, in contrast, generally carry only a single rider and are used in residential environments at all hours of the day and night. There are thus persuasive social arguments that their noise emission should be reduced to that applicable to passenger

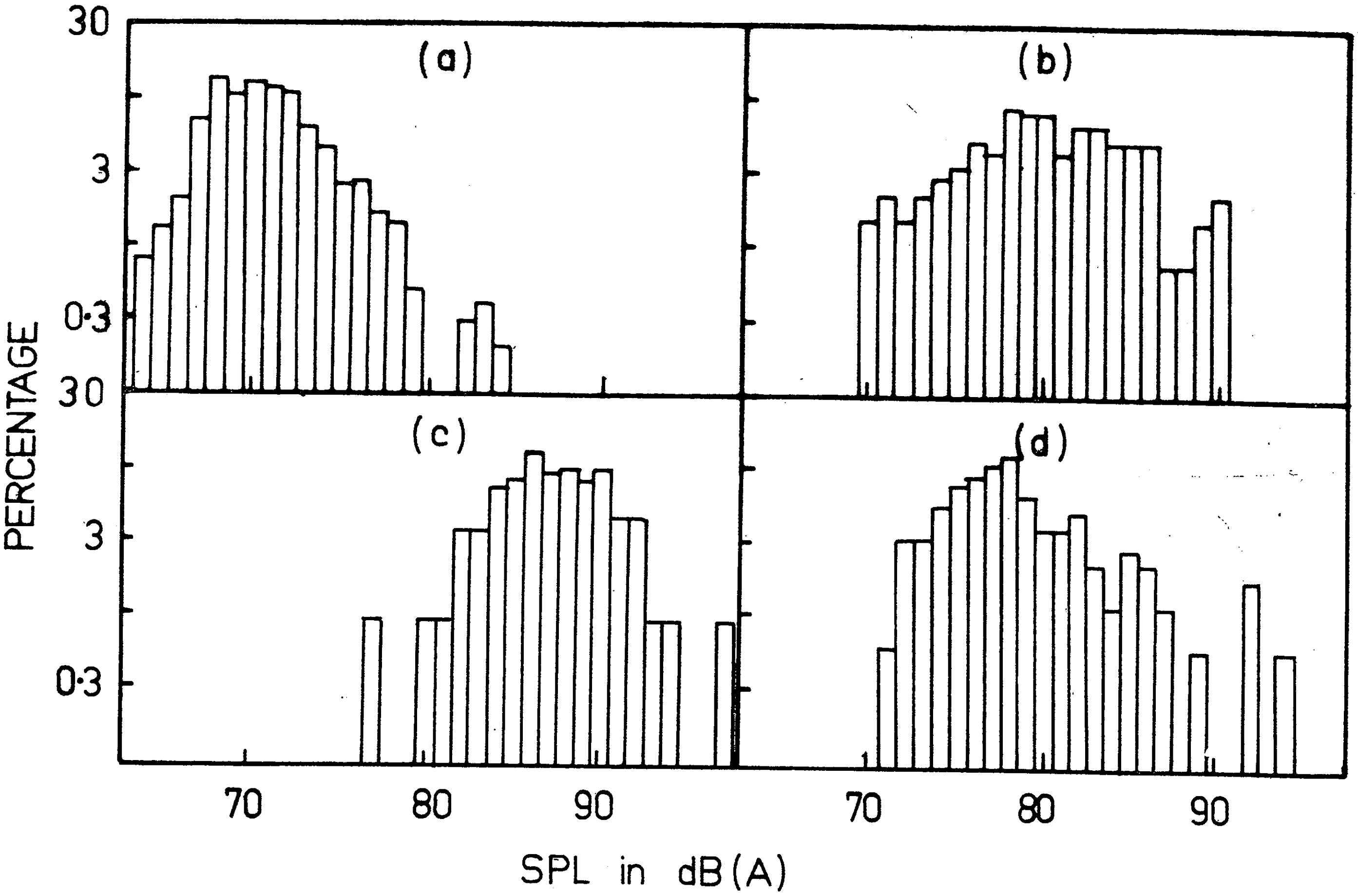

Figure 1: Histograms giving the percentage occurrence of measured noise levels within 1 dB classes for (a) passenger cars and other light vehicles, (b) heavy vehicles, (c) heavy articulated vehicles, and (d) motor cycles. Note that the percentage scale is logarithmic.

cars, though the technical problems and penalties in efficiency may in fact prevent this from being a feasible aim.

To examine the problem further, a selection of 34 motor cycles ranging in capacity from 90 to 1000 cm^3, from 1 to 4 cylinders and of both 2 and 4-stroke design was tested against the requirements of ADR28 (using the sub-classification on engine capacity) and of NCA 1975. Measurements showed that 20 of the 34 cycles failed to meet the requirements of ADR28, 9 of these having obviously modified or defective exhaust systems. All cycles however met the limit of 100 dB(A) at 3000 rpm and 0.5 metres from the exhaust specified by the simplified form of NCA 1975.

The correlation between ADR28 and NCA 1975 sound levels, which is shown in Fig. 2, is interesting. The relationship is obviously quite nonlinear and, for the noisier cycles, the narrow NCA 1975 range from 94 to 98 dB(A) allows ADR28 noise levels ranging from 89 to 100 dB(A). Comparison of these levels for individual cycles with those measured during normal riding of the vehicle up a hill showed poor correlation in both cases, so this was then made the subject of a more detailed study to be described in the next section.

Finally, since the NCA 1975 test is very attractive for general monitoring use, an analysis was made, for the 34 cycles in the sample, of the correlations between exhaust noise measured at different engine speeds. These correlation coefficients are shown in Table 2

TABLE 2
CORRELATION COEFFICIENT (R) FOR EXHAUST NOISE AT DIFFERENT ENGINE SPEEDS (R.P.M.)

	2000	3000	4000	5000	6000
2000	1.00	0.96	0.95	0.92	0.86
3000		1.00	0.98	0.95	0.90
4000			1.00	0.98	0.94
5000				1.00	0.97

and are clearly all very high. This suggests that, since simplicity and availability of measurements are of more importance than absolute accuracy in community noise monitoring, it might be reasonable to specify noise requirements at one engine speed only, say 3000 rpm, rather than in the more complex way envisaged in the Act. A set of such equivalent noise levels is shown in Table 3. It is interesting that to a first approximation

TABLE 3
APPROXIMATELY EQUIVALENT NOISE LIMITS FOR MOTOR CYCLES, MEASURED IN ACCORD WITH SCHEDULE 3 OF THE NOISE CONTROL ACT 1975
ENGINE SPEED (R.P.M.)

2000	3000	4000	5000	6000
85	90	93	97	103
90	95	99	103	110
95	100	105	110	
99	105	110		

the relationship corresponds to an increase of 5 dB(A) for an increase of 1000 rpm in engine speed in only mild distinction with the 15 dB(A) increase for a doubling of engine speed quoted by Delany (1974).

4. TYPICAL CYCLE OPERATING NOISE

In order to assess typical operational noise emission from a vehicle, it is desirable that this be monitored during a considerable time and with differing road conditions and drivers. Such monitoring is more easily carried out for a motor cycle than for most other vehicles since the principal source of noise is the exhaust.

With this in mind a condenser microphone, protected by an appropriate nose-cone turbulence shield (Bruel and Kjaer 4135 half-inch microphone with UA0386 nose cone) was fitted in turn to each of a variety of motor cycles in a position similar to that specified in NCA 1975 but only about 0.2 m from the exhaust exit. The cycle carried an appropriate power supply and cassette recorder to record the microphone signal. Calibration was set by operating the engine at 3000 rpm while making a standard NCA 1975 measurement, and the recorder gain was then locked. This procedure automatically allows for the differences between individual microphone placings and relates the measurements directly to the NCA 1975 standard situation. The owner of the cycle then rode it over a standard course typical of traffic-free suburban conditions and occupying about 7 minutes of riding time. The cassette was then replayed through a data capture system to sample the A-weighted noise level at about one second intervals and a statistical analysis was made of the results. A simple listening test was used to confirm that turbulence noise was at no stage significant in comparison with exhaust noise. Four typical histograms are shown in Fig. 3, with NCA 1975 calibration marked in each case.

TABLE 4

MEASURED NOISE CHARACTERISTICS OF MOTOR CYCLES ON TEST COURSE

Cycle type	NCA 1975 level dB (A)	Mean level & S.D. dB (A)	Peak level dB (A)
Suzuki 125	90	99.0 ± 5.3	105
Yamaha 125	91	99.4 ± 5.2	105
Yamaha 175	90	91.7 ± 2.4	96
Suzuki 250	96	98.0 ± 3.8	102
Honda 250	90	95.5 ± 4.6	103
Honda 250	—	94.5 ± 2.5	101
Suzuki 370	94	96.3 ± 3.6	101
Yamaha 400	84	87.4 ± 2.2	93
Honda 500	90	93.4 ± 3.3	98
BMW 600	96	94.6 ± 4.4	101
Kawasaki 750	88	87.8 ± 3.7	97
BMW 900	89	91.6 ± 7.4	103

It is clear that the noise emission level has a rather wide range about its mean and that this mean is rather higher than the NCA 1975 level. Details are given in Table 4. Particular values are not necessarily typical of the particular cycle type quoted since muffler condition and rider habits varied widely. The NCA 1975 levels are, however, a good guide to the noise emission from these cycles, as is shown in Fig. 4, which gives the distribution of mean noise emission levels above the measured NCA 1975 levels. Leaving out of account for the moment the two small 125 cm³ cycles, which presumably had large noise levels because they were necessarily operated under nearly full-throttle conditions over much of the rather hilly course, the average excess is about 2 ± 3 dB(A). Within these limits and with the exception of the small cycles, the NCA 1975 levels are thus a reasonable indicator of average noise emission in typical operation. Indeed the correlation is remarkably good when the variation in cycle types and riding habits is taken into account.

5. CONCLUSIONS AND RECOMMENDATIONS

It was clear to all the people involved in the measurement programme that, though all the motor cycles tested fulfilled the legal requirements of NCA 1975, many of them were extremely noisy. It seems manifest that the limits specified under this act should be progressively and substantially tightened, probably by as much as 10 dB(A). The fact that this may require extensive modification of some cycles and even put others off the road should be regarded as necessary consequences of any effective legislation.

In addition it may be useful to recognise that cycles with small engine capacity appear to have average

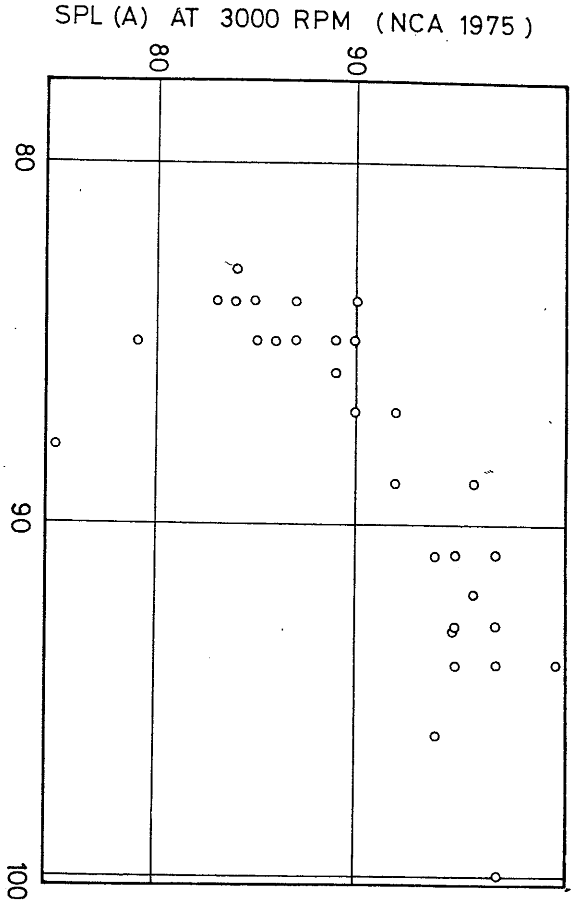

Fig. 2: Scatter diagram of the correlation between motor cycle noise levels as measured in an acceleration test (ADR 28) and a static test (NCA 1975).

noise emissions much higher than the NCA 1975 levels because of their typical operation at much higher throttle settings. This tentative conclusion is based upon a lamentably small data sample, but it does seem to suggest that a revised Act should incorporate lower permitted noise levels for engines of small capacity, as does ADR28. Such a feature would in any case appear reasonable on general grounds.

Finally we turn to one other aspect of motor vehicle noise control legislation that appears worthy of comment. ADR28, ADR28A and NCA 1975 properly specify the use of general-purpose or precision sound level meters complying with the requirements of Publication 179 (1965) of the International Electrotechnical Commission (IEC 179). Such meters are accurate and reproducible within ±1 dB over the important part of the frequency range and their filter characteristics are closely controlled. Unfortunately they are expensive and this expense (more than $500) limits their availability and use.

We have seen, however, that the noisiness of many vehicles is gross and that furthermore the actual noisiness during operation may vary considerably. A rather less precise instrument of ready availability, together with a judicious allowance for possible error, might therefore be of assistance in controlling motor vehicle noise.

Such simple sound level meters are available from radio hobby shops for less than $50. They incorporate A and C filter weightings and fast and slow meter response. A check of two of these instruments

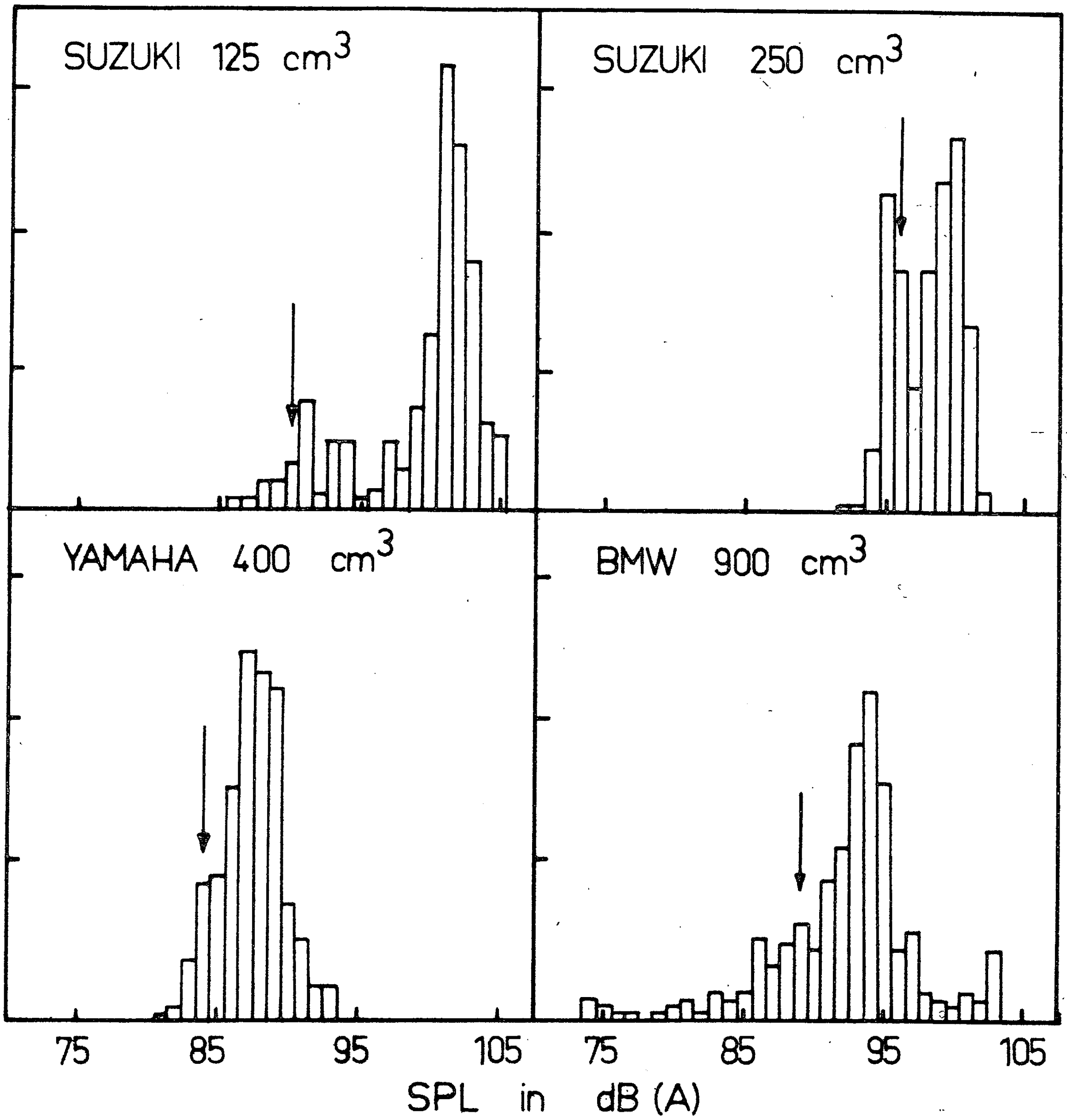

Figure 3: Histograms of exhaust noise level distributions for four typical motor cycles ridden around a suburban test course by their owners. The ordinate in this case is linear and the arrow in each figure shows the static 3000 r.p.m. noise level measured in accord with NCA 1975.

(Realistic 42-3019, randomly chosen and in condition as bought from the shop, against a properly calibrated high quality sound level meter showed an initial calibration error of less than 1 dB at 1000 Hz and agreement with it to within 1 dB(A) when measuring sound levels for several motor cycles in accord with NCA 1975. It is this second observation that is more significant since the frequency response of the simple meter may not be adequately accurate for use with pure-tone signals at other frequencies.

Obviously a comparably inexpensive calibrator is needed to ensure continued reliability, but this observation makes it feasible to require an exhaust noise check for all vehicles during registration inspection (hopefully in conjunction with much stricter standards) together with provision of such meters to all police traffic patrols for objective assessment of noise violations.

ACKNOWLEDGEMENTS

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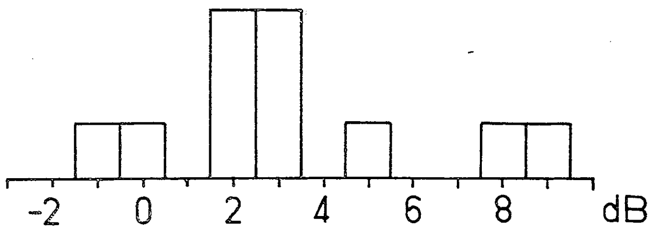

Figure 4: Histogram of the excess of the mean noise level around the test course over the static 3000 r.p.m. level measured in accord with NCA 1975. The highest two excesses apply to two cycles of capacity 125 cm³.

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