ICSV14
Cairns • Australia
9-12 July, 2007

14th International Congress on Sound & Vibration

REPEATABILITY OF CPX TYRE/ROAD NOISE MEASUREMENTS

Gillian Adams, Frits Kamst and Stephen Pugh

ASK Consulting Engineers, Brisbane, Australia

frits@askce.com

ABSTRACT

Road traffic is the main source of environmental noise in Australia due to the extensive road network and the tendency for people to be located near major roads.

The main component of road traffic noise is caused by the interaction of the road surface and the vehicle tyres for speeds in excess of approximately 60 to 70 km/h.

A CPX (Close Proximity Method) dynamic test rig has been developed and tested to measure the road/tyre interaction noise using the CPX method outlined in committee draft ISO 11819:2.

Testing has previously been undertaken to show compliance of the CPX test rig with the certification procedures in ISO 11819:2. The certification test procedures assess the capability of the CPX test rig to shield measurement equipment from other noise sources while approximating a free field environment in a semi-enclosed chamber.

In addition to the certification tests, ISO 11819:2 nominates theoretical repeatability values for the measurement procedure. Potential impacts on the repeatability include temperature, test tyre load, equipment set-up and calibration, and accurate location of the test section of road. The intent of recent testing is to gain an understanding of the influence of these impacts and to demonstrate the measurement repeatability of the CPX 'ROAD EAR' test rig. This study includes a review of the test data and a comparison of the test data with the ISO nominated repeatability values.

1. INTRODUCTION

The ASK Consulting Engineers CPX trailer has been developed over a period of time. A previous paper (Adams *et al*. 2006) discussed the results of tests which demonstrated compliance with the draft ISO11819:2 standard.

A further series of tests was carried out to determine the repeatability of the results. In other words, given the same conditions, can it be demonstrated that the noise levels generated by the tyre/road interaction over the same stretch of road are within an allowable margin?

In addition, the differences in noise levels generated with ‘cold’ tyres and ‘warmed up’ tyres were investigated.

2. DESIGN OF TEST

A test strip was selected along a 100m section of the Pacific Motorway between Brisbane and the Gold Coast. The site is shown in **Figure 1**. The road comprises an 8 lane median divided road with an open-graded asphalt surface. The speed limit along this section of road is 110 km/h.

The test strip, comprising the outer lane of the southbound traffic lanes, is indicated in **Figure 1**. No reflective surfaces, other than the road itself, are within 2m of the measuring microphones.

The CPX ‘ROAD EAR’ trailer was towed at a speed of approximately 80 km/h (22.2 m/s). At this speed a 20m segment is covered in approximately 0.9s and a 100m section is covered in 4.5s.

The monitoring equipment comprised Type 1 microphones with the data stored in two RION NA-27 Third Octave Band sound level analysers. Noise level data was obtained in terms of 1/3 octave bands in the range 12.5 Hz to 12.5 kHz at intervals of 0.1s.

Six (6) passes were completed along the test strip on Friday 20 April 2007 between midday and 3pm. The atmospheric conditions were quite steady during this period with an average temperature of approximately 25°C.

The testing was carried out for two scenarios: (i) Tests 1 to 3 comprise tests when the test tyre was not properly warmed, and (ii) Tests 4 to 6 comprise tests for which the test tyre was properly warmed as required by draft ISO11819:2 standard.

Personnel used for the tests comprised a driver and an equipment operator.

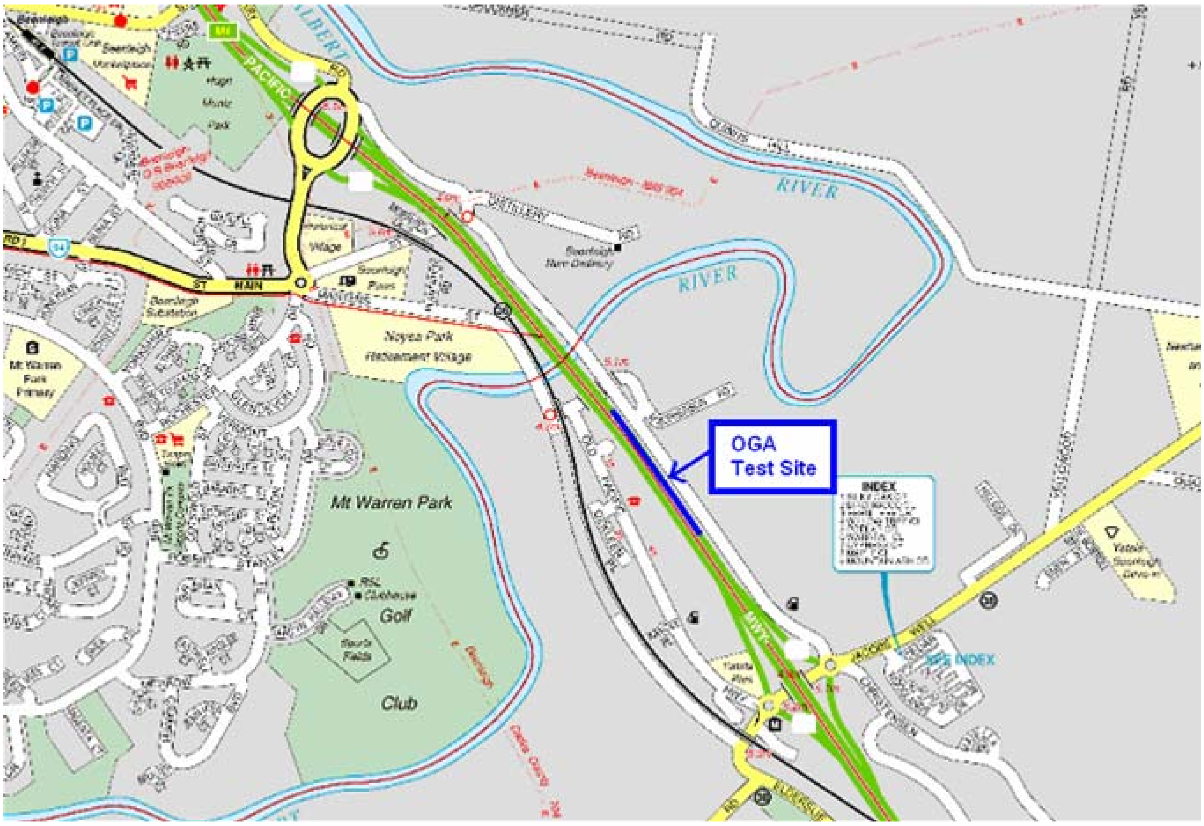

Figure 1. Test Site Location

3. VEHICLE LOCATION

One of the essential elements of the testing is to ensure that the vehicle position is known accurately to within 5m. This was achieved by beginning the noise measurement on a bridge with audible bridge joints, located immediately prior to the test location. The noise of the bridge joints was easily detectable in the noise level results so that each data set could be located to within 0.1 s (i.e. approximately 2m) of each other.

4. VEHICLE SPEED

Vehicle speed was determined by using a GPS device connected to a laptop computer. The GPS software was set to record position and velocity in one second intervals.

Figure 2 shows the vehicle speeds obtained for each of the 30 segments (6 tests each of 5 segments of 20m) tested; the range of vehicle speeds was 80.2 km/h to 81.7 km/h. The average speed for each test over the 100m section ranged from 80.5 km/h to 81.1 km/h. All of these speed ranges are well within the allowable limits prescribed in the draft ISO standard. The maximum variation in the speeds for each test ranged from 0.2 km/h for Test 1 to 0.7 km/h for Test 2.

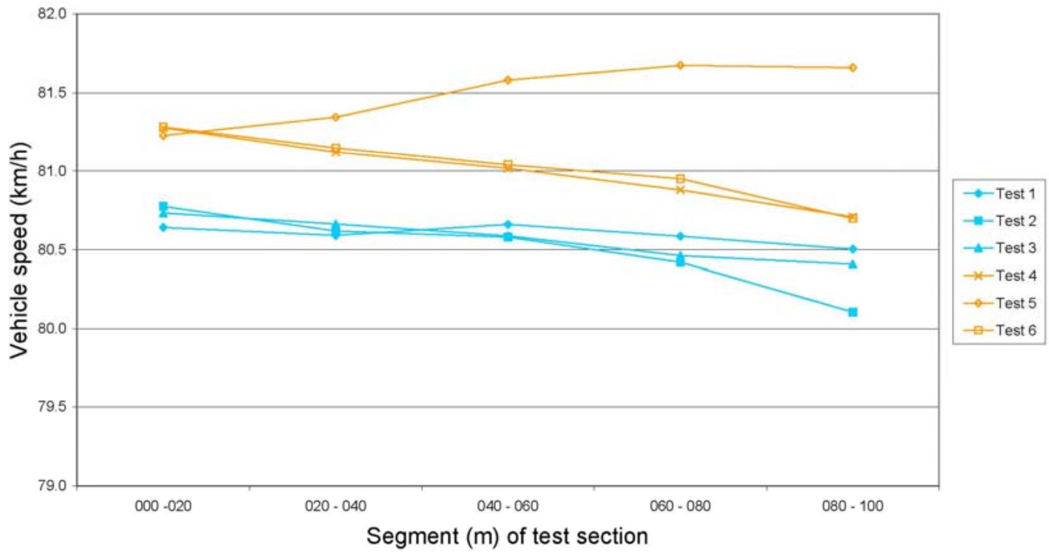

Figure 2. Recorded Vehicle Speeds

5. NOISE LEVEL COLLECTION

Noise level data was obtained in terms of A-weighted overall noise levels as well as in terms of A-weighted 1/3 octave bands. Noise levels were measured every 0.1 s using the two microphones, located in front of and behind the test wheel, as per draft ISO11819:2 standard. The noise levels obtained simultaneously at the front and rear of the test wheel were then averaged.

- The averaged noise levels were then adjusted to a speed of 80 km/h using the formula $L_{corr} = L_{meas} + B*\log(v_{ref}/v)$, contained in draft ISO11819:2 standard, where

- ‘v’ is the measured speed;
- ‘v_{ref}’ the reference speed,;
- ‘L_{meas}’ the measured noise level; and
- ‘L_{corr}’ the corrected noise level.
- The speed constant ‘B’ has the default value of 35.

The method of data collection means that for every vehicle speed determination, 10 noise levels are collected. In terms of arriving at a standardised noise level at 80 km/h, it was assumed that the average vehicle speed calculated over 1 second applies to each of the 10 noise levels obtained during this period.

Only the overall dB(A) results in terms of a standardised 80 km/h vehicle speed are discussed in this paper.

6. DISCUSSION OF RESULTS

Figure 3 shows a comparison of the results obtained for Tests 1 to 3 (pre ‘warm-up’ phase) and Tests 4 to 6 (post ‘warm-up’ phase).

Figure 4 shows a comparison of the results obtained for Tests 1 to 3 and Tests 4 to 6 averaged over 20 m segments. The results indicate that when the tyre is not ‘warmed up’ properly, the noise levels are on average 1.1 dB(A) higher than when it is ‘warmed up’ properly. It is concluded that ‘warming up’ of the tyre properly is an important part of the methodology.

The results in **Figure 4** also indicate differences in noise levels between the 20m segments. Segments 060-080 and 080-100 returned the highest noise levels. This is true for Tests 1 to 3 as well as for Tests 4 to 6.

For Tests 4 to 6 the average noise level over the 100m section was 94.0 dB(A). The lowest noise level obtained was 93.6 dB(A) in the 000-020 segment, with the highest being 94.2 dB(A) in the 060-080 segment.

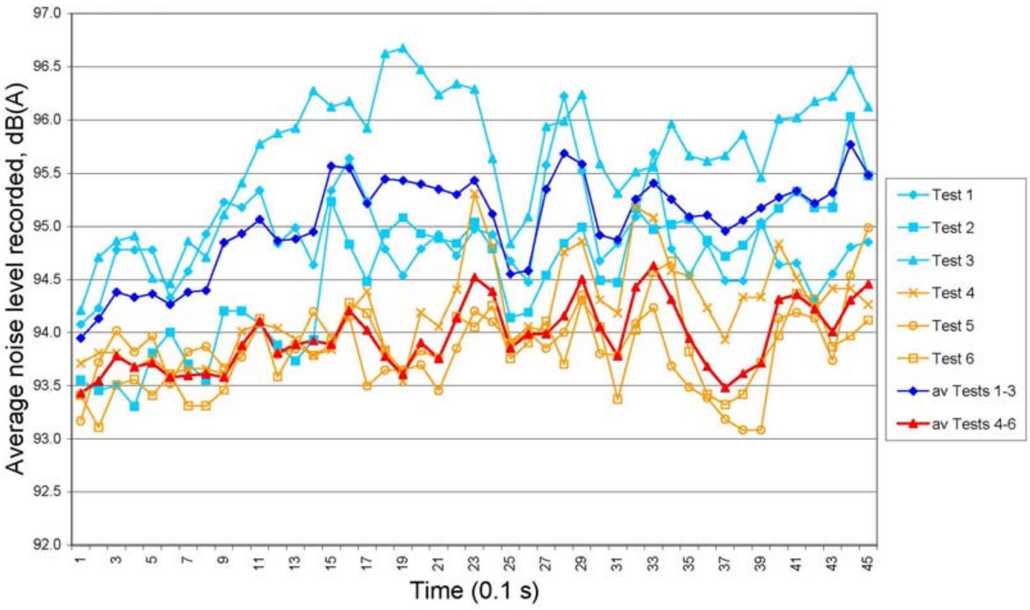

Figure 3. Noise Level Recorded Every 0.1 seconds

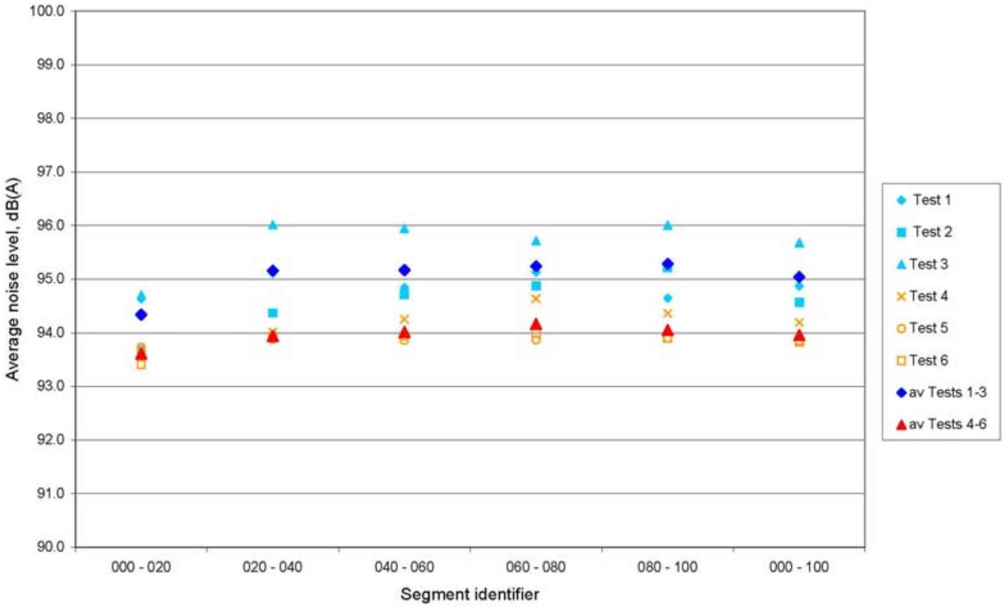

Figure 4. Average Noise Levels Recorded over 20m Segments

7. REPEATABILITY

The draft ISO11819:2 standard requires at least five road segments of 20m. It also requires a sufficient number of runs to give a total measured distance of 200m.

The repeatability criterion in the draft ISO11819:2 standard is stated as follows: "*The experimenter shall design his experimental program such that a standard deviation between different runs on a particular test section of not more than 0.5 dB should be obtained, after speed corrections*".

In our experiment the test section comprised five segments of 20m, making a total of 100m for the test section. Therefore to comply with the 200m total distance requirement, at least two runs were required.

Tests 4 to 6 were carried out in accordance with the draft standard and the results of these tests were further analysed in terms of repeatability. The analysis has been carried out for pairs of test results to determine whether the repeatability criterion of a standard deviation of 0.5 dB(A) is complied with using two runs.

Table 1 shows the results obtained. It may be noted that the standard deviation between each pairs of tests is less than 0.5 dB(A). This means therefore that the required accuracy is achieved using two runs for the same section of road.

Table 1. Standard Deviations For Pairs of Tests

Test Pairs	Standard Deviation
4 & 5	0.2
4 & 6	0.3
5 & 6	0.0

8. CONCLUSIONS

The results of the tests highlight the importance of ‘warming up’ the tyres as per draft ISO11819:2 standard.

The data collected also indicates that the repeatability criterion of a maximum standard deviation of 0.5 dB(A) was met using two runs only.

REFERENCES

[1] Gillian Adams, Frits Kamst, Stephen Pugh and Dave Claughton, *Dynamic Measurement of Tyre/Road Noise (2006)*, ASK Consulting Engineers, Brisbane, Australia, pp 1-5

[2] Australian State of the Environment Committee Members (2001) *Australian State of the Environment 2001* CSIRO Publishing, Australia

[3] Duhs, T., Renew, W. & Eddington, N. (1989) *Brisbane Noise Survey 1986 – 1989* Department of Environmental Heritage, Queensland

[4] Federal Department of Environmental Heritage (2006), *Your Home Technical Manual 5.3 Noise Control*, viewed 11th July 2006 http://www.greenhouse.gov.au/yourhome/technical/fs53.htm

[5] ISO/CD 11819:2 (2000): Acoustics – Method for Measuring the Influence of Road Surfaces on Traffic Noise – Part 2: the Close Proximity Method. International Organisation for Standardisation (ISO), Geneva, Switzerland

[6] J. Jones, W. (2005) *Quiet Pavement – Coming to a Highway Near You*, pp 24 – 25 of Asphalt, Summer 2005 Asphalt Institute, USA

[7] Sandberg, U. & Ejsmont, J.A. (2002) *Tyre/Road Noise Reference Book*, Informex, Sweden