inter noise
2013 | INNSBRUCK | AUSTRIA
15.-18. SEPTEMBER 2013
NOISE CONTROL FOR QUALITY OF LIFE

Reduction, tonal assessment and monitoring of motocross noise

Frans Schermer[11]

Peutz bv

Paletsingel 2, 2718 NT Zoetermeer, Netherlands

ABSTRACT

Measurements were carried out in order to determine the effect of improved exhaust silencing of motocross bikes. Based on the measurement results the Dutch motorsport federations reduced the prescribed pass-by noise level at 7.5 m to 94 dB(A), 4 to 6 dB(A) lower than the preceding noise limits. A survey was carried out in 2012 in order to determine the effect of the 94 dB(A) noise limit on the sound power level emitted by motocross courses. The results of this study show that an average reduction of the sound power level of 3 to 5 B(A) is realistic.
The audibility of tones in motocross noise has been assessed, using ISO 1996-2, Annex C. The analysis shows that motocross noise should not be characterized as tonal noise.

A new monitoring system has been developed, using two microphones, with a mutual distance of 15 m. The average pass-by noise level at 7.5 m is calculated from the two signals and linked to the driver by means of a transponder system. The noise and transponder data are wirelessly transferred to a computer or mobile device, so the monitoring system can be used to guard the noise limits given by the environmental permit.

1. INTRODUCTION

In 2006 an acoustical survey was carried out by Peutz in order to establish the average sound power levels of motocross bikes and motocross courses in Holland. The outcome of this survey was an average sound power level per bike of 118 dB(A) during practice (training) and 120 dB(A) in competition (racing).
In the past the Dutch motorsport federations allowed the use of both static noise testing and pass-by noise testing. In the static noise test the sound pressure level at 0.5 m from the exhaust opening at fixed rpm is determined. The dynamic pass-by test as prescribed by KNMV and MON requires measurement of the noise level at 7.5 m of the drive line in a full throttle situation. The pass-by noise L_{AS} level is the maximum value with the sound level meter on “Slow” time response, i.e. 1 second time integration. The Peutz-survey of 2006 showed a poor correlation between static noise test and the dynamic pass-by test. This poor correlation was attributed to the fact that during the static noise test engine load (and thus engine power output) is comparatively low. This situation is not in accordance with real world driving conditions, where the full throttle situation determines the average sound emission. Currently, only the pass-by noise test is used by KNMV and MON.
The 2006-survey also indicated that a significant noise reduction would be possible by means of using

[1] f.schermer@peutz.nl

improved exhaust silencers.

Since 2006, an increasing number of motocross clubs in The Netherlands have been facing problems in permitting procedures. A number of motocross courses even have been forced to close due to noise issues. KNMV and MON decided that it was necessary to make a significant step in reducing the noise. In February 2010 initial noise tests took place with 10 randomly selected motocross bikes. For these bikes pass-by noise levels were determined using respectively the OEM exhaust and a tailor made exhaust system, as shown below. This improved exhaust system has an additional small expansion chamber near the engine block and a larger end silencer with an additional expansion chamber inside.

The noise tests showed that the average pass-by noise level at 7.5 m of the 10 bikes amounted to:

- appr. 100 dB(A) using the OEM exhaust;
- appr. 93 dB(A) using the improved exhaust system.

Based on these measurement results, KNMV and MON decided to lower the pass-by noise limit to the value of 94 dB(A). The new 94 dB(A) pass-by noise limit was incorporated in the technical regulations from January 2011 onwards. Aim of the noise survey carried out in 2012 was to determine the status with respect to pass-by noise levels and the resulting total sound power level of motocross courses.

2. STRATEGY

In order to obtain information about the pass-by noise levels as well as the total sound power levels emitted by the motocross course, measurements were carried out around two motocross courses in the 2012 season: course A (new to the survey) and course B (from the 2006-survey). Firstly, pass-by measurements were carried out in order to determine if the 94 dB(A) noise limit could be met by the participants.

Secondly, measurements were carried out at various positions at distances up to appr. 400 m from the

outline of the track during training. By means of a calculation model, the total sound power level of the motocross course as a whole and the average sound power level per bike were determined in the same way as in the 2006-survey.

3. RESULTS OF MEASUREMENTS AND CALCULATIONS

The following training sessions were carried out at respectively course A and course B:

Course A:

- Session 1: 23 bikes: 12 bikes 4-stroke, 11 bikes 2-stroke
- Session 2: 12 bikes 4-stroke
- Session 3: 11 bikes 2-stroke

Course B:

- Session 1: 23 bikes: 12 bikes 4-stroke, 11 bikes 2-stroke
- Session 2: 12 bikes 4-stroke

The first session with a mix of 2-stroke and 4-stroke motocross bikes is currently representative for the majority of training (and racing) situations in Holland. The results of measurements and calculations for the two motocross courses are summarized in table 1.

Table 1 – Results of measurements and calculations

Course, Session	Pass-by noise level in dB(A) interval, average[1]	Number of bikes Exceeding the 94.0 dB(A)-limit	Sound power level per bike in dB(A)[2]
Course A, Session 1	86.0-99.1, av.96.4	18	115.8
Course A, Session 2	90.1-99.1, av.97.6	11	117.6
Course A, Session 3	86.0-97.3, av.94.8	7	115.4
Course B, Session 1	86.9-97.2 av.92.9	6	114.8
Course B, Session 2	88.7-97.2 av.93.9	5	114.8

[1] Energy equivalent average
[2] Average sound power level, based on measurements at larger distances from the motocross course

4. EVALUATION

The results differ significantly for course A and course B. Nearly 80% of the participants in the noise test at course A exceeded the 94 dB(A) noise limit. This is reflected in the average sound power level per bike (up to 117.6 dB(A)).

During the noise tests at course B the majority of the bikes complied with the 94 dB(A) noise limit, resulting in an average sound power level per motocross bike of about 115 dB(A).

It is expected that for the situation where all bikes have a pass-by noise level of 94 dB(A) (or lower) the average sound power level per bike will be 113 to 114 dB(A), dependent on a.o. the lay-out of the track.

The measurements carried out for the purpose for this survey show that the new Dutch 94 dB(A) noise limit set by the motorsport organisations KNMV in MON is an ambitious goal. However, comparing the current situation to the situation in 2006 (where the majority of the bikes had pass-by noise levels between 98 and 102 dB(A)) it can be concluded that by means of the new 94 dB(A) pass-by noise limit a reduction of environmental noise levels of 3 dB(A) to 5 dB(A) is realistic.

5. ASSESSMENT OF TONES IN MOTOCROSS NOISE

5.1 General

In ISO 1996-2, Annex C (2007) an objective method is described in order to verify the presence of audible tones. The method has three steps:

- narrow-band frequency analysis of the signal;
- determination of the average sound pressure level of the tone(s) and of the masking noise within the critical band around the tone(s);
- calculation or the tonal audibility ΔL_{ta}, and the adjustment Kt.

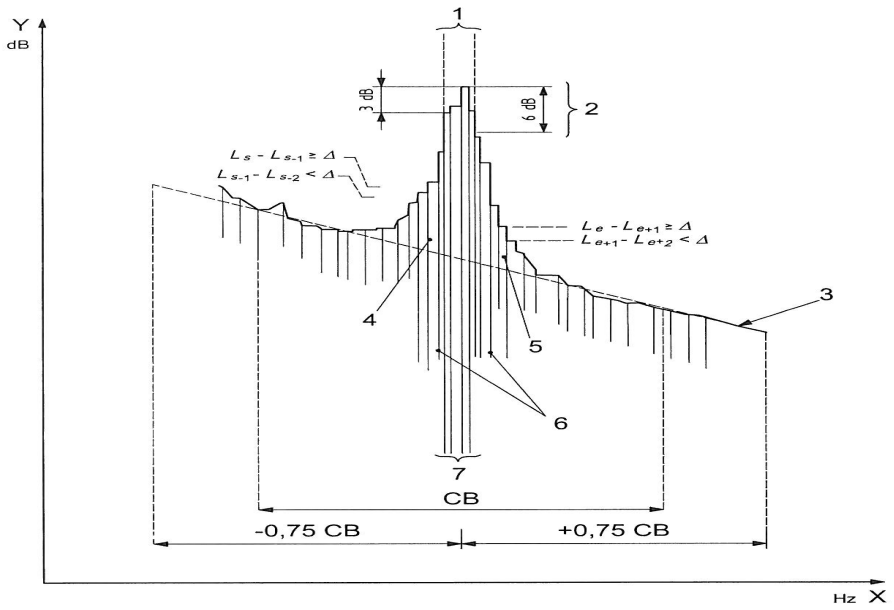
In the last step the adjustment Kt is determined based on the difference (ΔL_{ta}) between sound pressure level of the masking noise within a critical band (L_{pn}) and the sound pressure level of the tones within the critical band (L_{pt}):

for $\Delta L_{ta} > 10$ dB: $K_T = 6$ dB

for $4 \text{ dB} \leq \Delta L_{ta} \leq 10$ dB: $K_T = \Delta L_{ta} - 4$ dB

for $\Delta L_{ta} < 4$ dB: $K_T = 0$ dB

The critical bandwidth is 100 Hz for components between 50 and 500 Hz. All local maxima with a 3 dB bandwidth smaller than 10% of the bandwidth of the actual critical band are regarded as a tone, as shown in the figure below.



Key

1 tone when the 3 dB bandwith is less than 10 % of the critical band
2 tonal energy
3 linear regression line of the noise level
4 noise-pause start
5 noise-pause end
6 neither tone nor noise
7 tone
CB critical band

Figure C.2 — Definitions of tones, noise and noise pause (neither tone nor noise). △ is the tone-seek criterion and is normally chosen as 1 dB

According to ISO 1996-2, Annex C, the critical bandwidth method should be based on a narrow-band A-weighted spectrum, linearly averaged over a period of at least 1 min. The ISO-standard also states that for situations with fluctuating frequencies, shorter averaging periods may be used.

5.2 Tonal analysis of motocross noise

The noise level caused by one or more motocross bikes has (potentially) tonal components, which fluctuate strongly with engine RPM. Averaging the narrow-band signal over a period of 1 minute (as recommended by ISO 1996-2, Annex C) would almost certainly result in a relatively “flat” spectrum and would lead to an adjustment K_T of 0 dB. For this reason additional samples have been analyzed which were the result of averaging over periods of respectively 15 seconds and 5 seconds. For each of the motocross courses A and B approximately 100 samples were analyzed. The results of the analysis for the training sessions at respectively motocross course A and B were as follows:

course A: 3 samples gave a $K_T > 0$ dB (values resp. 1.3, 3.0 and 5.9 dB)
course B: 1 sample gave a $K_T > 0$ dB (value of 0.2 dB).

Samples for which a $K_T > 0$ dB was found were all from sessions 1 (mix of 2-stroke and 4-stroke bikes) or 3 (only 2-stroke bikes) and were averaged over either 5 or 15 seconds. Based on these results it is safe to conclude that the presence of audible tones is no longer a factor to take into account when assessing noise due to a motocross course. The improved silencing of the exhaust, which is necessary to comply with the 94 dB(A) pass-by noise limit, contributes to this non-tonal characteristic.

6. MUNISENSE/PEUTZ NOISE MONITORING SYSTEM

In order to facilitate the monitoring of the 94 dB(A)-noise limit, a fully automated dynamic noise monitoring system has been developed by Munisense in collaboration with Peutz. This measurement system uses two small wireless meters, with a mutual distance of 15 m, as shown below.

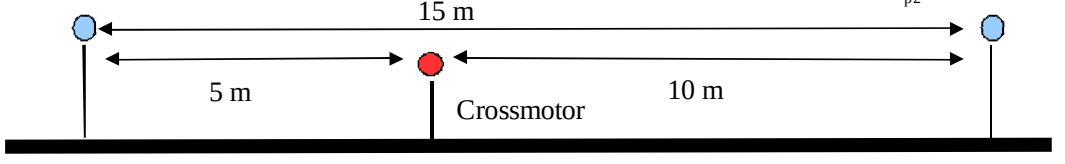
The pass-by noise level L_p at 7.5 m is calculated from the two signals L_{p1} and L_{p2} by means of the following formula:

$$L_{p7,5m} = -13\mathrm{Log}\left(10^{\left(\frac{(-9-L_{p2})}{13}\right)} + 10^{\left(\frac{(-9-L_{p1})}{13}\right)}\right) - 5.1$$

Example:

L_{p1}: 96.3 dB(A)

L_{p2}: 92.4 dB(A)



L_{p1} measured	L_{p2} measured	→	$L_{p7,5m}$ calculated
96.3	92.4		94.0

The noise level is linked to the driver by means of a transponder system. Only valid passages (for which there is sufficient distance between two contenders) are taken into account by the system. The data is transferred by means of wireless internet to a gateway, which is connected to a computer or mobile device. Live data can be shown and the results are logged and traceable.

7. CONCLUSIONS

The recently introduced pass-by noise limit for motocross bikes of 94 dB(A) has led to a significant reduction of the noise emission of motocross bikes and motocross courses in The Netherlands. Compared to the last survey in 2006, the average sound power level per bike during practice (training) has come down from about 118 dB(A) to about 115 dB(A). It is expected that the latter value can be reduced by another 1 to 2 dB(A) to 113-114 dB(A) when all participants comply with the 94 dB(A) noise limit.
In order to facilitate this process, a measurement system has been developed, which allows for constant monitoring of individual pass-by noise levels. Because this measurement system also generates information about the number of laps of each bike, the system can be used to guard the noise limits given by the environmental permit.

Analysis using the critical bandwidth method as described in ISO 1996-2, Annex C shows that the noise due to a motocross course should no longer be characterized as “tonal”. The improved silencing of the exhaust, which is necessary to comply with the 94 dB(A) pass-by noise limit, eliminates the most dominant tones of the exhaust.

REFERENCES

[1] F.A.G.M. Schermer, J. van Hees, “Onderzoek met betrekking tot de geluidemissie van motorcrossmotoren en motorcrossterreinen” – “Survey with respect to noise emission of motocross bikes and motocross tracks” (Zoetermeer, 2006).

[2] ISO 1996-2 - Description, measurement and assessment of environmental noise - –Part 2: Determination of environmental noise levels (2007).