

NOISE CONTROL FOR QUALITY OF LIFE

Noise performance of the SRTT tyre compared to normal passenger car tyres

Truls Berge¹

¹ SINTEF ICT, Dept. of Acoustics

P. O. Box 4760, Sluppen, NO-7465 Trondheim, Norway

ABSTRACT

Within the NORDTYRE project, the tyre/road noise from a range of passenger car tyres has been measured on 10 normally used dense asphalt concrete road surfaces (SMA and DAC) in Norway. The aim of the project is to compare the noise behaviour of commonly used passenger car tyres with the noise on an ISO surface, which is the basis of the newly introduced tyre labelling system in Europe. A total of 31 tyres from the NORDTYRE project including the Uniroyal Tigerpaw SRTT tyre and 9 tyres from a previous project have been measured on the same road surfaces. CPX measurements have been made on road surfaces in Norway, Sweden and Denmark, as well as on an ISO surface. Only the measurements on the Norwegian road surfaces are reported in this paper. The quietest tyres are about 4-5 dB quieter than the noisiest tyre on all 10 road surfaces. The quietest tyre on the quietest dense road surface is approximately 8 dB quieter than the noisiest combination of tyre and road surface. The measurements confirm that the SRTT tyre is a good choice of a tyre to represent tyre/road noise from passenger car tyres on Norwegian dense surfaces. Keywords: Noise, Tyres, Measurement

1. INTRODUCTION

Tyre/road noise is the major contribution to traffic noise, under steady speed driving conditions from about 30 km/h and upwards for light vehicles. To evaluate the contribution of the road surface to the tyre/road noise level, the CPX method (ISO/DIS 11819-2) has been developed and is now ready for final approval and publication in 2013. The method is based on the use of two reference tyres; P1 representing noise levels of from light vehicle tyres and H1 representing heavy vehicle tyres. These reference tyres are specified in a new ISO Technical Specification (TS), which currently has a status as a working draft from ISO TC43/SC1/WG42 (ISO/WD for TS 11819-3). As tyre P1, the Uniroyal Tigerpaw ASTM Standard Reference Test Tyre (SRTT) has been proposed, while the Avon AV4 is presently the candidate for the H1 tyre.

Originally, the test tyre representing light vehicle tyres was the Avon ZV1. In 2006/7, this tyre was replaced by the Uniroyal Tigerpaw ASTM SRTT, as the Avon tyre was no longer in production and available. Since then, the SRTT tyre has been used by many institutions performing CPX measurements. Normally, the CPX results with the SRTT tyre has been compared to Statistical Pass-by

¹ truls.berge@sintef.no

measurements and a fairly good correlation has been found between the CPX levels and the SPB_{cars} -index [1, 2]. However, in the NordTyre project we have been able to compare the performance of the SRTT tyre more directly with a selection of frequently used passenger car tyres in the Nordic countries. The selected tyres include both premium types and budget types of tyres available on the Nordic market in 2012.

In this paper, the tyre/road noise levels (Lcpx) of 40 passenger car tyres on 10 different Norwegian road surfaces are reported. 31 of these tyres are part of the NordTyre project, and they have been measured on a wide range of pavements types in Norway, Sweden and Denmark in 2012.

2. TYRE SELECTED FOR MEASUREMENTS

Table 1 gives an overview of the technical data for the 31 tyres. 22 tyres are summer tyres, 4 are all-seasons tyres and 5 are non-studded winter tyres.

Tyres 1- 30 have been selected by the Danish Road Directorate for the NordTyre project. Tyre 31, Michelin Primacy LC was originally included in a previous Norwegian project and measured on selected road surfaces in Denmark in 2010. The Michelin Primacy LC tyre is especially developed for the Asian market and not commercially available in Europe. It has been advertised as a special low noise tyre. This tyre was bought from Hong Kong by VTI of Sweden in 2010.

The results from the Danish road surfaces indicated that this tyre was 2-3 dB quieter than average of the 7 summer tyres tested [3]. It was nearly as quiet as a non-studded winter tyre. It was therefore decided to include this tyre in the NordTyre project to study the noise behaviour on other surfaces, like in Sweden and Norway, as well as other surfaces in Denmark.

The ATM SRTT is tyre no. 30 in table 1. Note that this tyre is not commercially used on vehicles in Europe, only used for tyre performance testing.

In addition to the 31 tyres from the NordTyre project, 9 other tyres have been included in the analysis. In 2011, SINTEF measured these 9 tyres on the same road surfaces as chosen for the NordTyre project [4]. These measurements were made with the same CPX trailer (belonging to the Norwegian Public Roads Administration) as in the NordTyre project. Therefore, it was possible to include both sets of tyres in the analysis, to extend the number of tyres to 40. The technical data for the additional 9 tyres are given in table 2.

For the tyres in the NordTyre project, the Shore hardness was measured by the Danish Road Directorate (DRD), while this was measured by SINTEF for the 2011 set of tyres.

The same tyre was mounted on the left and right side of the trailer, and all the reported results are the average noise levels of these two sides.

						Shore hardness
Tyre no	Brand	Line	Dimension	Rim	Type ¹	Shore A ²
1	Goodyear	DuraGrip	185/60/R14	5½ J	S	70
2	Firestone	Multihawk	175/65/R14	5½ J	S	66
3	Continental	ContiEcoContact 3	175/65/R14	5½ J	S	71
4	Uniroyal	RainExpert	175/65/R14	5½ J	S	64
5	Michelin	Energy Saver	175/65/R14	5½ J	S	67
6	Klebér	Dynaxer HP3	175/65/R14	5½ J	S	70
7	Nankang	Ultra Sport NS II	155/65/R14	5½ J	S	66
8	Bridgestone	Turanza ER300 Ecopia	205/60/R16	7 J	S	67
9	Firestone	Multihawk	195/65/R15	6 J	S	65
10	Continental	ContiPremiumContact 2	205/55/R16	7 J	S	71
11	Uniroyal	Rainsport 2	205/50/R16	7 J	S	65

Table 1 – Technical data for the tyres in the NordTyre project (2012)

12	Michelin	Energy Saver	205/60/R16	7 J	S	69
13	Klebér	Dynaxer HP2	205/60/R16	7 J	S	71
14	Nankang	Ultra Sport NS II	195/45/R16	7 J	S	65
15	Bridgestone	Turanza T001	225/55/R16	7 J	S	70
16	Hankook	Kinergy ECO K425	215/65/R15	6 J	S	67
17	Continental	ContiPremiumContact 5	225/55/R16	7 J	S	69
18	Marshal	Matrac XM	225/60/R16	7 J	S	71
19	Тоуо	Proxes C1S	225/60/R16	7 J	S	62
20	Dunlop	SP Sport 01 MO	225/50/R16	7 J	S	69
21	Goodyear	Vector 4seasons	185/65/R14	5½ J	А	62
22	Bridgestone	A001	205/55/R16	7 J	А	69
23	Hankook	Optimo 4S	205/65/R15	6 J	А	62
24	Klebér	Quadraxer	205/55/R16	7 J	А	65
25	Firestone	Winterhawk 2 EVO	175/65/R14	5½ J	W	61
26	Klebér	Krisalp HP2	175/65/R14	5½ J	W	65
27	Hankook	Winter i*cept evo	205/60/R15	6 J	W	65
28	Michelin	Alpin A4	205/60/R16	7 J	W	62
29	Nokian	WR D3	205/60/R16	7 J	W	61
30	Uniroyal	Tigerpaw SRTT	225/60/R16	7 J	S	64
31	Michelin	Primacy LC	205/60/R15	6 J	S	65

¹S= Summer, A= All-seasons, W=Winter, ²Measured by DRD 03.07.2012, just prior to the measurements in Norway

						Shore hardness
Tyre no	Brand	Line	Dimension	Rim	Туре	Shore A
32	Uniroyal	Tigerpaw SRTT	225/60/R16	7 J	S	70
33	Тоуо	330	185/65/R15	5 ½ J	S	72
34	Michelin	Energy Saver	205/65/R15	5 ½ J	S	70
35	Continental	ContiPremiumContact 2	195/65/R15	6 J	S	72
36	Continental	ContiEcoContact 3	195/65/R15	5 ½ J	S	72
37	Nokian	Hakka H	205/55/R16	6 J	S	72
38	Michelin	Pilot Primacy HP	215/55/R16	6 J	S	70
39	Pirelli	P7	205/65/R15	7 J	S	65
40	Yokohama	AVS dBV500	185/65/R15	5 ½ J	S	75

Table 2 – Technical data for the tyr	es measured by SINTEE (2011)
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Comparing the two sets of tyres, there are 4 sets of tyres that are of the same brand and line: - Tyres 30 and 32: The SRTT-tyres. Tyre 32 are the "old" SINTEF SRTT tyres, manufactured in 2006 and due to a too high Shore A value (of 70 units), they have now been replaced by new tyres in 2012. Tyre 30 is new SRTT tyres provided by DRD.

- Tyres 12 and 34: Michelin Energy Saver. There is a slight difference in profile and size; 60/R16 for Tyre 12 and 65/R15 for tyre 34.

- Tyres 10 and 35: ContiPremiumContact 2. Tyre 10 is a little wider, and with a lower profile than tyre 35 (205/55 vs. 195/65).

- Tyres 3 and 36: ContiEcoContact 3. Tyre 3 are smaller than tyre 36; 175/65 vs. 195/65.

In the analysis (figures 2 to 5), these 4 sets are marked individually to make a visual comparison easier.

3. ROAD SURFACES SELECTED FOR MEASUREMENTS

The road surfaces in Norway were chosen according to the following criteria:

- Representative of the most common type of road surfaces in Norway

- Road surfaces likely to have different levels of tyre/road noise

- All road surfaces should have been exposed to more than one winter season with studded tyres (i.e. no completely new road surfaces)

- Road surfaces that were geographically close to each other, in order to save time and costs to complete the measurement program.

Two different locations with a total of 10 test sections were chosen; see table 3.

Surface Surface Section Production length, m no Location type year 1 E18 Mastemyr SMA16 260 2005 2 SMA11 2005 E18 Mastemyr 260 3 E18 Mastemyr SMA8 260 2005 E18 Mastemyr SMA6 2005 4 220 5 E18 Mastemyr SMA11 340 2005 E16 Hønefoss DAC11 2005 6 380 E16 Hønefoss DAC6 2005 7 340 8 E16 Hønefoss DAC8 280 2005 9 E16 Hønefoss DAC11 340 2005 10 E16 Hønefoss DAC11 500 2002

Table 3 – Road surfaces selected for measurements in Norway

As table 3 shows, only dense surfaces have been included, with variation in maximum chipping size from 6 to 16 mm. Nine of the pavements have been constructed in 2005, while no.10 is from 2002. This means that all the pavements had been exposed to winter conditions for 7 to 10 years at the time of the measurements in 2012.

4. MEASUREMENT LAY-OUT

4.1 Noise measurements

All the noise measurements were performed using the CPX trailer of the Norwegian Public Roads Administration. This trailer is equipped with the measurement system PAK MK II, with the software PAK 5.6. At each test section, one run at the test speed of 80 km/h was made. The results are the average of left and right wheel track. The analysis of the results was made with the CPX Inspector 1.4.556.

4.2 Vehicle speed measurements

The vehicle speed was measured, using an independent GPS system on the towing vehicle. The cruise control of the towing vehicle was used to obtain a vehicle speed as close to 80 km/h as possible. No speed correction of the noise level has been made. It is assumed that the actual vehicle speed is within ± 2 km/h. This represent a noise variation of approximately ± 0.3 dB, assuming that the noise is dependent on the speed with 30·logv/v_{ref}.

4.3 Temperature measurements

The air temperature was measured just before and after each run, and the average is reported, arithmetically rounded to the nearest whole digit. Each noise level has been temperature corrected to a reference temperature of + 20 °C, using a temperature correction of -0.05 dB/°C.

5. MEASUREMENT RESULTS

Tables 4 and 5 give a summary of the main results for the 10 different surfaces. Vehicle speed: 80 km/h. The average A-weighted level, Lcpx is shown, with standard deviation. In addition, the range (maximum and minimum levels) is shown. Based on the average of these 40 tyres, there is a potential reduction of about 3 dB(A) by changing the road surface from a SMA16 to a SMA6. The noise range for these tyres are from 3,6 dB (SMA6) to 4,9 dB.

	8	1			
Surface no.	No.1	No.2	No.3	No.4	No.5
Туре	SMA16	SMA11	SMA8	SMA6	SMA11
Lcpx, average, dB(A)	101,8	100,8	100,4	99,1	99,6
St.deviation, dB(A)	1,1	1,1	1,0	1,2	1,2
Max, dB(A)	103,8	102,8	101,1	100,1	102,2
Min, dB(A)	99,8	98,7	97,2	96,5	98
Range, dB(A)	4	4,1	3,9	3,6	4,2

Table 4 – Average Lcpx-levels on the SMA surfaces

Table 5 – Average Lcpx-levels on the DAC surfaces

Surface no.	No.6	No.7	No.8	No.9	No.10
Туре	DAC11	DAC6	DAC8	DAC11	DAC11
Lcpx, average, dB(A)	99,6	99,1	99,2	98,5	97,9
St.deviation, dB(A)	1,3	1,0	1,3	0,9	1,3
Max, dB(A)	101,5	100,5	101,3	101,7	101,8
Min, dB(A)	96,7	95,6	96,4	97,2	97,1
Range, dB(A)	4,8	4,9	4,9	4,5	4,7

In figure 1, the results for the 2012-set of tyres (table 1) are shown for all 10 road surfaces. The road surfaces with the largest stone sizes are shown to the left and those with the smallest are shown to the right. The range between the noisiest tyre on the noisiest road surface to the quietest tyre on the quietest road surface is 8 dB. The ranking seems to shift somewhat on the DAC surfaces, compared to the SMAs. This is clearly the case with tyre 12, which is the noisiest tyre on all the DAC surfaces.



Figure 1 – Lcpx, dB(A). 31 tyres measured on 10 road surfaces

In figures 2-4, the results are shown for 4 of the measured road surfaces (with reference to table 3):

- 1. Surface 1: SMA16 at E6 Mastemyr
- 2. Surface 4: SMA6 at E6 Mastemyr
- 3. Surface 6: DAC11 at E16 Hønefoss
- 4. Surface 7: DAC6 at E16 Hønefoss

The results from these surfaces have been chosen, as they represent the surfaces with the largest and smallest maximum chipping sizes at the two locations. In the figures, the SRTT tyres are marked with red colour ("new" SRTT are tyre 30 and "old" SRTT are tyre 32). In addition, the two sets of Michelin Energy Saver (dark purple), ContiPremiumContact2 (lavender) and ContiEcoContact3 (light green) are shown. The winter and all-season tyres have also separate colours; blue for winter and yellow for all-season tyres.



Figure 2 - Lcpx, dB(A). 40 tyres measured on road surface no.4, SMA16



Figure 3 - Lcpx, dB(A). 40 tyres measured on road surface no.4, SMA6



Figure 4 – Lcpx, dB(A). 40 tyres measured on road surface no.6, DAC11



Figure 5 – Lcpx, dB(A). 40 tyres measured on road surface no.7, DAC6

These figures show that the winter and all-seasons tyres, in general are among the quietest tyres (with tyre 22 as an exception). This is understandable, as the measurements were done at temperatures between 14 and 19 °C. At these temperatures; the rubber gets softer on the winter/all-seasons tyres and thus produce less noise. A better solution would be to also test these tyres around 0 °C, or below, as this is the temperatures were these tyres are normally used. The two sets of the Michelin Energy Saver (tyres 12 and 34) and the two sets of the ContiPremiumContact2 (tyres 10 and 35) have comparable noise levels on all surfaces, while the two sets of ContiEcoContact3 (tyres 3 and 36) rank very

differently. Tyre 3 is about 3 dB more silent than tyre 36. This can be somewhat related to differences in tyre dimensions; 175/65 (tyre 3) vs. 195/65 (tyre 36).

On the SMA surfaces it seems that SRTTs are close to the average tyre noise level, while on the DAC surfaces, they rank among the noisiest. Even if the oldest SRTT have a Shore hardness that is 6 units higher than the new SRTT, this seems not to influence the ranking of the SRTTs too much. Only on the SMA16, the newest SRTT are about 1 dB quieter than the older set. However, on the SMA6 and on the DAC surfaces, there is no significant difference in noise levels.

One of the goals of this analysis was to check the noise performance of the SRTT type compared to the "average" passenger car tyre on Norwegian roads. In figure 6, the average of the 30 tyres (table 1) is compared with the level of the SRTT on the 10 surfaces at the two locations. In addition to the average level, the 95 % confidence interval is also shown. Note that the confidence interval of the 30 tyres is related to the variation of noise levels of this batch of tyres, while the confidence interval of the SRTT is related to the variation in Lcpx-level over the measured distance at each road surface.

In figures 7 and 8, the linear regression on the two categories of pavements types is shown for the same comparison between the average of the 30 tyres and the SRTT.



Figure 6 – Comparison between average of 30 tyres and SRTT



average of 30 tyres, SMA surfaces.

average of 30 tyres, DAC surfaces.

These results show that there is a good correlation between tyre/road noise level of the SRTT and average of normally used tyres, especially on the SMA surfaces. On the DAC surfaces, the correlation is somewhat weaker, mainly due to the results on one of the surfaces; DAC8.

6. CONCLUSIONS

The 31 sets of tyres in the NordTyre project have been measured on 10 different surfaces in Norway. The surfaces are the same 5 surfaces at E18 Mastemyr (SMA; 6 to 16 mm maximum stone sizes) and the 5 surfaces at E16 Hønefoss (DAC; 6 to 11 mm), that were used as test surfaces in a similar project in 2011, financed by the Climate and Pollution Directorate. In this project, 9 different sets of summer tyres were measured, using the same CPX trailer as in the NordTyre project. The data from the NordTyre project could therefore be compared with the results from 2011.

The following main conclusions can be made:

• There is a spread in noise levels of about 4-5 dB(A) on all the surfaces measured, when 40 tyres are compared

• The noise ranking of tyres is in general quite similar on all the surfaces

• The maximum noise level difference between the noisiest tyre on the noisiest road surface (SMA16) and the quietest tyre on the quietest road surface (DAC6) is approximately 8 dB. This is an indication of the potential noise reduction of tyre/road noise, if an optimal tyre and road combination is used, even if no porous road surfaces are included in this comparison.

• 4 all-seasons and 5 winter tyres (non-studded) tyres were part of the 31 tyres. They have been measured at temperatures around 14-19 °C. This is could be considered out of the normal temperature range for the use of these types of tyres. The relatively low noise levels measured for these tyres are clearly influenced by this.

• The Michelin Primacy LC proved to be one of the quietest tyre on all surfaces.

• The Uniroyal Tigerpaw ASTM SRTT is proposed as reference tyre P1 in the ISO/TS 11819-3, currently under development, and as a representative tyre for the noise behaviour of passenger car tyres. The results from the measurement on the commonly used Norwegian road surfaces confirm that this is a good proposal.

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