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ELANORE Improvement of the EU tyre labelling system for noise and rolling resistance

Technical report from the test program of CPX noise measurements

Main author:	Piotr Mioduszewski		
Contact details:	pmiodusz@pg.edu.pl		+48 603 052 234
Co-authors:	Truls Berge, Ryszard Woźniak		
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1 INTRODUCTION

One of the main objective of the ELANORE project is to verify representativeness of the tyre/road noise test methods specified in UNECE Regulation 117 (*Uniform provisions concerning the approval of tyres with regard to rolling sound emissions and/or to adhesion on wet surfaces and/or to rolling resistance*) [1] used directly in the Tyre Labelling Directive. It is expected that representativeness of the standard reference road surface proscribed in the ISO 10844:2014 [2] in relation to conventional pavements in Poland and Norway will not be very satisfactory.

Thus, based on the obtained results from the Round Robin Test (RRT) of the selected ISO test tracks (conducted in WP2) together with the results from performed road noise tests on selected conventional, most common dense and porous pavements in Poland and Norway as well as the results form laboratory noise measurements on the GUT drum facility equipped with different road replica surfaces, an improved tyre labelling procedure will be elaborated and proposed. It is expected, that the new procedure correlates much better with real road conditions than the present one. This will be the most important result of WP4 *Development and evaluation of improved method of tyre/road noise measurements*.

Road noise measurements, using the CPX method, presented in this technical report were performed for the test tyres selected in WP1 (tyres that were dedicated mainly to noise tests) on selected conventional, most common pavements in Poland and Norway, with the main aim to estimate the correlation between road (CPX) and laboratory (drum) measurements.

2 TESTING PROGRAM

2.1 TEST TYRES

For the purpose of noise tests performed in ELANORE project, 9 different C1 tyre types (4 of them in sets of 4 tyres) covering the range of EU label noise values from 66 dB up to 74 dB with 1 dB step (1 to 3 noise bars) were selected and purchased within WP1. Only one selected tyre from each tyre set was tested using the CPX method. The selected tyres consisted of 4 summer tyres, 3 winter and 2 all-season tyres. Additionally, one set consisting of 4 pcs. of "Standard Reference Test Tyre" - SRTT (Uniroyal Tigerpaw) according to the ASTM F2493-14 was also purchased and one tyre was also selected from this tyre set for CPX measurements. Furthermore, the standard reference tyre (Avon Supervan AV4), designated H1 according to the technical specification ISO/TS 11819-3:2017 [3] was used in CPX tests.

The details of all 11 selected and tested tyres were presented in Table 1.

Table 1. *Description of the selected tyres for CPX tests*

Designation	Manufacturer	Tread pattern	Season	Tyre size	Load index	Speed rating	Remarks	DOT	Tread rubber hardness				Noise level
										FUEL EFFICIENCY	WET GRIP	ROAD NOISE	
T1252	Dębica	PRESTO UHP	Summer	215/55R17	94	W		**3216**	**74**	E	C		**66** dB
T1254	Yokohama	Advan Fleva V701	Summer	215/55R17	94	W		**3720**	**68**	C	A		**67** dB
T1257	Kenda	KR501	Winter	215/55R17	98	V	XL	**2420**	**61**	E	C		**68** dB
T1259	Michelin	CrossClimate+	All season	215/55R17	98	W	XL	**4920**	**63**	C	B		**69** dB
T1262	Vredestein	Ultrac Satin	Summer	215/55R17	98	W	XL	**1021**	**65**	B	A		**70** dB
T1264	Bridgestone	Blizzak LM005	Winter	215/55R17	98	V	XL	**4820**	**64**	C	A		**71** dB
T1267	Continental	AllSeasonContact	All season	215/55R17	98	H	XL	**1121**	**63**	A	B		**72** dB
T1268	Momo	W-2 NORTH POLE	Winter	215/55R17	98	V	XL	**2520**	**67**	E	C		**73** dB
T1269	Evergreen	EH23	Summer	215/55R17	98	V	XL	**1620**	**71**	E	C		**74** dB
T1273	Uniroyal	Tiger Paw	SRTT	P225/60R16	97	S		**4020**	**66**	-	-	-	**-**
T1182	Avon	AV4	AAV4	195R14C	106/104	N		**4814**	**71**	-	-	-	**-**

2.2 TEST CONDITIONS

Noise measurements were performed with tyre load and inflation pressure according to the values prescribed in the UNECE Regulation 117 [2], as well as with a modified test condition named "Light Test 2" in this report.

According to the UNECE Regulation No.117 the tyre load and inflation pressure depend on the maximum load of tested tyres. Using the formulas given in Reg.117 the tyre load was calculated to be 530 kg – uniform for all the selected tyres. The inflation pressure was also same for all tyres and it was 200 kPa. These test conditions were designated "R117" in this technical report.

In the modified test conditions, named Light Test 2 and designated "LT'", the tyre load was reduced to 320 kg while the inflation pressure remained unchanged (230 kPa). Such tyre load is used in the standardized CPX method [4] and is much more feasible for a regular CPX trailer. Using this load it was also possible to compare results of CPX measurements performed on ISO test tracks performed under the Work Package 2 of this project.

The measurements were performed with two test speeds of 50 and 80 km/h. The measured pavements were clean and dry, air temperatures were close to 20 °C with two exceptions: on EACC (LT' test conditions only) – about 10 °C and on SMA11 (both test conditions) – within a range from 30 to 35 °C.

2.3 TEST VEHICLES

The reported tyre/road noise measurements using the CPX method were performed using the GUT's CPX test trailer *Tiresonic Mk5*. Additionally, on the two pavements in Norway, the Norwegian trailer joined the measurements.

2.3.1 POLISH CPX TEST TRAILER

All CPX measurements conducted within the ELANORE project were performed using the modernized CPX trailer of GUT, *Tiresonic Mk5* (see Figure 1).

Figure 1. *Polish CPX trailer, Tiresonic Mk5*

The trailer has one test wheel at the rear and two supporting front wheels. The test wheel is enclosed in a semi-anechoic protective chamber. Noise generated by free rolling tyre (2 channel SPLs and 3rd-octave bands) is acquired using two microphones placed in the close proximity of the contact patch. Fully computerized measuring and data acquisition system, based on portable 4 channel *B&K PULSE* equipment is used. Noise averaged over each 10 m long road segment is synchronized with speed, ambient air and road surface temperatures as well as with GPS position.

Within the ELANORE project Work Package 4, Task 4.1, the CPX test trailer, property of GUT, has been completely modernized to accommodate test conditions specified in the EU Tyre Labelling procedure (much higher tyre load), to be prepared for the extensive measurement program (to speed-up numerous measurements) and to provide high level measurement precision at all times (new measuring sensors have been purchased and installed).

2.3.2 NORWEGIAN CPX TEST TRAILER

Tyre/road noise measurements conducted on Norwegian roads were additionally performed also by SINTEF using the CPX trailer owned by the Norwegian Public Roads Administration (see Figure 2).

Figure 2. *Norwegian CPX trailer*

The trailer has two test wheels enclosed in protective semi-anechoic chambers. Noise generated by two test tyres is measured by 4 microphones (2 per tyre) connected to the front-end of PAK system. The speed of the towing vehicle for the Norwegian trailer is measured with a dynamic GPS device from Racelogic (V-Box) at the same time as the noise levels and air and road temperatures.

Unfortunately, a short time before the start of the measurement campaign, it was discovered that the Racelogic no longer functioned as normal. There was no time for repair and no replacement device available in Norway on short notice. Recording of vehicle speed was therefore not possible. Instead, a GPS based speed measuring app on a mobile phone was used to control the vehicle speed as close as possible to 50 and 80 km/h (a default value of 50 and 80 km/h has been applied in the pre-processing tools). This introduces a measurement uncertainty which in this case was unavoidable.

2.4 TEST LOCATIONS

CPX measurements on conventional pavements were performed in the summer of 2022 on 5 road sections: 2 in Norway and 3 in Poland. The two road sections in Norway and one section in Poland were under regular traffic conditions. The remaining two road sections in Poland were located on newly built high-speed roads just before they were opened to traffic.

In Norway measurements were done on two road surface test sections located on trafficked roads in southern part of the country:

1. Pavement **MA11**, located on road Fv1190 close to Skjeberg village. “MA” is a Norwegian name for a "soft asphalt". It is a dense surface with 11 maximum chipping size. Mostly used on low trafficked roads with few heavy vehicles. This pavement was constructed in the summer of 2021, and due to very low ADT (600), the surface seemed to have very little wear after one year. The location of the measurements was on a flat section of the road and with a speed limit of 80 km/h. Figure 3 shows a photo from the measurement location, Figure 4 - a detail of the road surface texture.

Figure 3. *Measurement location at Fv1190, Skjeberg (Norway)*

Figure 4. *MA11 road surface*

2. Pavement **SMA16**, located on road Fv171 close to Sørum town. This surface was constructed in 2018 and located at a section of the road with ADT approximately around 6000. The test location was on a flat section with a speed limit of 80 km/h. Figure 5 shows a photo from the measurement location and Figure 6 a detail of the road surface texture.

Figure 5. *Measurement location at Fv171, Sørum (Norway)*

Figure 6. *SMA16 road surface*

In Poland noise measurements were performed on three road surface test sections, two of them (SMA8 and SMA11) were located in northern part of the country and one section (EACC) in eastern part:

1. Pavement **SMA8**, located on a local road close to Bartoszylas village with a speed limit of 90 km/h. This road was repaved in 2019 and is of a very low local traffic only. Surrounding farmlands provided very good acoustics conditions. Figure 7 shows a photo from the measurement location, Figure 8 - a detail of the road surface texture.

Figure 7. *Measurement location at Bartoszylas (Poland)*

Figure 8. *SMA8 road surface*

2. Pavement **SMA11**, located on the newly built S6 high-speed road in northern Poland close to Szemud town. It was built at the turn of 2021/2022, finished in May 2022 but at the time of measurements (July 2022) the road was still closed to the traffic. Figure 9 shows a photo from the measurement location, Figure 10 - a detail of the road surface texture.

Figure 9. *Measurement location at Szemud (Poland)*

Figure 10. *SMA11 road surface*

3. Pavement **EACC**, located on the newly built S61 high-speed road in north-eastern Poland close to Ełk town. The road surface at the location of test section was laid in 2021 and at the time of measurements (June 2022) the road was still closed to the traffic. Figure 11 shows a photo from the measurement location, Figure 12 - a detail of the road surface texture.

Figure 11. *Measurement location at Ełk (Poland)*

Figure 12. *EACC road surface*

2.5 ACHIEVED MEASUREMENT PROGRAM

CPX tests were conducted in the time period from May 31st to July 29th, 2022. On all Norwegian and Polish roads, measurements under the test conditions according to Reg.117 have been fully completed. Measurements under Light Test conditions (LT') at EACC pavement in Poland have been performed for 5 of 11 tyres only, due to rain fall. The completed test program was shown in Table 2.

Table 2. *Completed test program on conventional roads*

Tyre no	Manufacturer	CPX tests completed									
		MA11		SMA8		SMA11		SMA16		EACC	
		R117	LT'	R117	LT'	R117	LT'	R117	LT'	R117	LT'
1	Yokohama	x	x	x	x	x	x	x	x	x	x
2	Michelin	x	x	x	x	x	x	x	x	x	x
3	Bridgestone	x	x	x	x	x	x	x	x	x	x
4	Evergreen	x	x	x	x	x	x	x	x	x	x
5	SRTT Uniroyal	x	x	x	x	x	x	x	x	x	x
6	Dębica	x	x	x	x	x	x	x	x	x	
7	Kenda	x	x	x	x	x	x	x	x	x	
8	Vredestein	x	x	x	x	x	x	x	x	x	
9	Continental	x	x	x	x	x	x	x	x	x	
10	Momo	x	x	x	x	x	x	x	x	x	
11	Avon AV4	x	x	x	x	x	x	x	x	x	

3 MEASUREMENT RESULTS

All measurement results presented in this chapter of this technical report were corrected for speed and temperature but were not corrected for tyre rubber hardness. The corrections applied were calculated according to the Annex of the ISO 11819-2:2017 [4] standard.

3.1 NOISE LEVELS

The results of measurements, A-weighted sound pressure levels of the average of front and rear microphones, were presented in Table 3 for the R117 test conditions and in Table 4 for LT' ones. Please observe that not all tyres were tested on EACC pavement under LT' test conditions due to unpredicted unsatisfactory weather conditions (rainfalls).

Table 3. *Noise levels of tested tyres under R117 test conditions*

Tyre	Sound Pressure Level [dB] - R117 test conditions													
	50 km/h							80 km/h						
	SMA8	SMA11	SMA16	MA11	EACC	**Average**	***Spread***	SMA8	SMA11	SMA16	MA11	EACC	**Average**	***Spread***
T1252	89,4	91,5	94,8	87,1	90,7	**90,7**	***7,7***	96,0	98,4	102,3	93,8	97,9	**97,7**	***8,6***
T1254	87,8	90,8	94,3	85,4	89,8	**89,6**	***8,9***	94,5	97,6	102,2	91,9	97,2	**96,7**	***10,3***
T1257	87,1	89,2	91,3	85,1	88,0	**88,1**	***6,2***	93,9	96,1	99,6	91,7	95,9	**95,4**	***7,9***
T1259	87,6	90,2	92,7	86,0	89,0	**89,1**	***6,7***	94,7	97,3	100,7	92,8	96,5	**96,4**	***7,9***
T1262	88,0	90,5	93,7	86,3	89,5	**89,6**	***7,5***	94,5	97,3	101,5	92,9	96,8	**96,6**	***8,6***
T1264	89,4	91,1	92,7	87,4	89,5	**90,0**	***5,3***	95,5	97,8	100,6	93,4	96,8	**96,8**	***7,2***
T1267	88,9	91,2	93,4	87,7	90,0	**90,2**	***5,7***	96,1	98,5	101,3	94,6	97,7	**97,7**	***6,7***
T1268	89,9	92,1	94,4	87,9	90,9	**91,0**	***6,5***	97,0	99,2	102,5	95,1	98,8	**98,5**	***7,5***
T1269	88,5	91,2	94,8	85,6	90,2	**90,1**	***9,2***	95,3	98,1	102,6	92,6	97,6	**97,2**	***10,0***
T1273	89,9	92,1	95,0	88,4	91,1	**91,3**	***6,6***	96,0	98,6	102,4	94,4	97,9	**97,9**	***8,0***
T1182	90,6	92,0	93,8	89,6	91,0	**91,4**	***4,2***	97,6	98,6	101,0	96,2	98,1	**98,3**	***4,8***
max	90,6	92,1	95,0	89,6	91,1	91,4	9,2	97,6	99,2	102,6	96,2	98,8	98,5	10,3
min	87,1	89,2	91,3	85,1	88,0	88,1	4,2	93,9	96,1	99,6	91,7	95,9	95,4	4,8
avg	**88,8**	**91,1**	**93,7**	**86,9**	**90,0**	**90,1**	**6,8**	**95,5**	**97,9**	**101,5**	**93,6**	**97,4**	**97,2**	**7,9**
spread of tyres 1-9	***2,8***	***2,9***	***3,6***	***2,8***	***2,8***	***2,9***		***3,1***	***3,2***	***3,0***	***3,4***	***2,9***	***3,1***	

The obtained differences in sound pressure levels for particular tyre when tested on different pavement were up to 10 dB (6-8 dB on the average) independent on test conditions (R117 or LT'). The smallest differences were observed for the Avon AV4 reference tyre – about 4-5 dB. When excluding both CPX reference tyres form this analysis, the smallest difference was 5.9 dB.

Although the spread in noise levels given on tyre labels was 8 dB (from 66 up to 74 dB), the maximum spread in measured noise levels on particular conventional pavement under the R117 conditions was 3.6 dB for 50 km/h and 3.4 dB for 80 km/h (3.0 dB on the average). For the LT' test conditions the spread was comparable – the obtained maximum values were 3.7 dB and 3.2 dB correspondingly. This finding has an important influence on tyre ranking according to

measured sound levels when comparing with the tyre ranking according to the noise value given on the tyre label.

Table 4. *Noise levels of tested tyres under LT' test conditions*

Tyre	Sound Pressure Level [dB] - LT' test conditions													
	50 km/h							80 km/h						
	SMA8	SMA11	SMA16	MA11	EACC	**Average**	***Spread***	SMA8	SMA11	SMA16	MA11	EACC	**Average**	***Spread***
T1252	89,2	90,7	94,1	86,5		**90,1**	***7,6***	96,1	98,1	101,8	94,1		**97,5**	***7,7***
T1254	87,6	89,4	93,2	84,6	88,8	**88,7**	***8,7***	94,3	96,7	101,1	91,3	96,5	**96,0**	***9,9***
T1257	86,8	88,4	90,4	84,5		**87,5**	***5,9***	93,7	95,7	98,8	91,4		**94,9**	***7,3***
T1259	87,7	89,3	92,0	85,7	88,1	**88,5**	***6,4***	94,9	96,8	100,1	92,4	95,9	**96,0**	***7,7***
T1262	87,9	89,8	92,9	85,7		**89,1**	***7,2***	94,9	97,0	100,9	92,9		**96,4**	***8,0***
T1264	89,1	90,1	91,6	86,7	88,6	**89,2**	***4,9***	95,7	97,1	99,5	93,3	96,1	**96,4**	***6,2***
T1267	88,4	90,1	92,5	86,3		**89,3**	***6,2***	95,3	97,4	100,6	93,3		**96,6**	***7,3***
T1268	89,4	91,1	93,2	87,2		**90,2**	***6,0***	96,6	98,7	101,6	94,5		**97,8**	***7,1***
T1269	88,5	90,2	93,7	85,2	89,3	**89,4**	***8,5***	95,3	97,7	101,7	92,5	97,1	**96,8**	***9,2***
T1273	89,4	91,1	93,2	87,6	89,8	**90,2**	***5,6***	96,1	98,1	101,0	93,7	97,2	**97,2**	***7,3***
T1182	90,8	92,0	93,7	89,0		**91,4**	***4,8***	98,6	99,3	101,2	96,7		**99,0**	***4,5***
max	90,8	92,0	94,1	89,0	89,8	91,4	8,7	98,6	99,3	101,8	96,7	97,2	99,0	9,9
min	86,8	88,4	90,4	84,5	88,1	87,5	4,8	93,7	95,7	98,8	91,3	95,9	94,9	4,5
avg	**88,6**	**90,2**	**92,8**	**86,3**	**88,9**	**89,4**	**6,5**	**95,6**	**97,5**	**100,7**	**93,3**	**96,6**	**96,8**	**7,5**
spread of tyres 1-9	***2,6***	***2,7***	***3,7***	***2,7***	***1,2***	***2,7***		***2,8***	***3,0***	***3,0***	***3,2***	***1,2***	***2,9***	

3.2 TEST CONDITION INFLUENCE

The influence of different test conditions (tyre load and inflation pressure) on measured sound pressure levels were presented in Table 5.

Table 5. *Difference in noise levels of tested tyres under different test conditions*

Tyre	Difference in Sound Pressure Level between R117 and LT' test conditions [dB]													
	50 km/h							80 km/h						
	SMA8	SMA11	SMA16	MA11	EACC	**Average difference**	***Spread***	SMA8	SMA11	SMA16	MA11	EACC	**Average difference**	***Spread***
T1252	0,2	0,8	0,7	0,6		**0,6**	***0,6***	-0,1	0,3	0,6	-0,3		**0,1**	***0,9***
T1254	0,3	1,4	1,0	0,8	1,0	**0,9**	***1,1***	0,1	0,9	1,0	0,6	0,7	**0,7**	***0,9***
T1257	0,3	0,8	0,9	0,6		**0,7**	***0,5***	0,1	0,4	0,8	0,3		**0,4**	***0,7***
T1259	0,0	0,9	0,7	0,3	0,9	**0,6**	***1,0***	-0,2	0,5	0,6	0,4	0,6	**0,4**	***0,8***
T1262	0,1	0,7	0,8	0,5		**0,5**	***0,7***	-0,3	0,2	0,6	0,0		**0,1**	***0,9***
T1264	0,2	1,0	1,1	0,7	0,9	**0,8**	***0,9***	-0,2	0,7	1,1	0,1	0,6	**0,4**	***1,3***
T1267	0,5	1,1	0,9	1,4		**0,9**	***0,9***	0,8	1,1	0,8	1,4		**1,0**	***0,6***
T1268	0,5	1,0	1,2	0,7		**0,9**	***0,7***	0,4	0,5	1,0	0,6		**0,6**	***0,6***
T1269	0,1	1,1	1,1	0,4	0,9	**0,7**	***1,0***	0,0	0,4	0,9	0,1	0,5	**0,4**	***0,9***
T1273	0,5	1,0	1,8	0,8	1,3	**1,1**	***1,3***	-0,1	0,5	1,4	0,7	0,8	**0,7**	***1,5***
T1182	-0,3	0,0	0,1	0,7		**0,1**	***0,9***	-1,0	-0,7	-0,2	-0,6		**-0,6**	***0,8***
max	0,5	1,4	1,8	1,4	1,3	1,1	1,3	0,8	1,1	1,4	1,4	0,8	1,0	1,5
min	-0,3	0,0	0,1	0,3	0,9	0,1	0,5	-1,0	-0,7	-0,2	-0,6	0,5	-0,6	0,6
avg	**0,2**	**0,9**	**0,9**	**0,7**	**1,0**	**0,7**	**0,9**	**0,0**	**0,4**	**0,8**	**0,3**	**0,7**	**0,4**	**0,9**

The average difference between the R117 and LT' test conditions is, depending on a tyre, up to 1.0 dB for 50 km/h and 0.8 dB for 80 km/h. With the exception of Avon AV4 reference test tyre, and for half of the tyres when tested on SMA8 pavement with the speed of 80 km/h, for all other pavement/speed combinations the difference is positive and up to 1.8 dB (1.4 dB when excluding the SRTT tyre). Such a difference is not significant taking into account the advantages that the smaller load used is much more feasible for a regular CPX trailer. Especially that the tyre ranking on particular pavement according to its measured noise levels remains unchanged independent on test conditions (see next chapter 3.3).

3.3 TYRE RANKING

It was questionable, if the tyre ranking according to the noise value given on the tyre label corresponds with the ranking according to measured sound levels during CPX measurements on conventional pavements and on ISO reference road surface. The average value of SPLs at 80 km/h calculated for all ISO test tracks (the average of ISO2 and ISO4 test tracks in case of LT' test conditions) were used for this comparison. The obtained results were presented in Table 6 for tests performed under R117 conditions and in Table 7 under LT' ones.

Table 6. *Tyre ranking comparison for CPX measurements under R117 test conditions*

Tyre	Manufacturer	Tyre label		R117 test conditions, 80 km/h													
				SMA8		SMA11		SMA16		MA11		EACC		**Average of all pavements**		Average of all ISO test tracks	
		Noise bar	Noise level	SPL [dB]	Ranking position	SPL [dB]	Ranking position	SPL [dB]	Ranking position	SPL [dB]	Ranking position	SPL [dB]	Ranking position	**SPL [dB]**	**Ranking position**	SPL [dB]	Ranking position
T1252	Dębica	**1**	**66** dB	96,0	**7**	98,4	**7**	102,3	**7**	93,8	**7**	97,9	**8**	**97,7**	**8**	93,3	7
T1254	Yokohama	**1**	**67** dB	94,5	**2**	97,6	**4**	102,2	**6**	91,9	**2**	97,2	**5**	**96,7**	**4**	91,4	1
T1257	Kenda	**1**	**68** dB	93,9	**1**	96,1	**1**	99,6	**1**	91,7	**1**	95,9	**1**	**95,4**	**1**	91,9	2
T1259	Michelin	**1**	**69** dB	94,7	**4**	97,3	**3**	100,7	**3**	92,8	**4**	96,5	**2**	**96,4**	**2**	92,4	3
T1262	Vredestein	**2**	**70** dB	94,5	**3**	97,3	**2**	101,5	**5**	92,9	**5**	96,8	**4**	**96,6**	**3**	92,7	6
T1264	Bridgestone	**2**	**71** dB	95,5	**6**	97,8	**5**	100,6	**2**	93,4	**6**	96,8	**3**	**96,8**	**5**	92,5	4
T1267	Continental	**2**	**72** dB	96,1	**8**	98,5	**8**	101,3	**4**	94,6	**8**	97,7	**7**	**97,7**	**7**	93,4	8
T1268	Momo	**3**	**73** dB	97,0	**9**	99,2	**9**	102,5	**8**	95,1	**9**	98,8	**9**	**98,5**	**9**	95,5	9
T1269	Evergreen	**3**	**74** dB	95,3	**5**	98,1	**6**	102,6	**9**	92,6	**3**	97,6	**6**	**97,2**	**6**	92,6	5

One can easily observe that the tyre ranking based on CPX noise measurements is totally different from the one based on noise values given on tyre labels. Neither the quietest nor the loudest tyre according to its label corresponds to the noise levels measured for these tyres with the CPX method. The positions in the middle of the stake are also different. Differences appear also between particular conventional pavements. The ranking on conventional pavements differs also from the ranking on ISO test tracks.

Table 7. *Tyre ranking comparison for CPX measurements under LT' test conditions*

Tyre	Manufacturer	Tyre label		LT' test conditions, 80 km/h													
				SMA8		SMA11		SMA16		MA11		EACC		**Average of all pavements**		Average of all ISO test tracks	
		Noise bar	Noise level	SPL [dB]	Ranking position	SPL [dB]	Ranking position	SPL [dB]	Ranking position	SPL [dB]	Ranking position	SPL [dB]	Ranking position	**SPL [dB]**	**Ranking position**	SPL [dB]	Ranking position
T1252	Dębica	**1**	**66** dB	96,1	**8**	98,1	**8**	101,8	**9**	94,1	**8**			**97,5**	**8**	93,6	8
T1254	Yokohama	**1**	**67** dB	94,3	**2**	96,7	**2**	101,1	**6**	91,3	**1**	96,5	**3**	**96,0**	**2**	91,0	1
T1257	Kenda	**1**	**68** dB	93,7	**1**	95,7	**1**	98,8	**1**	91,4	**2**			**94,9**	**1**	91,9	2
T1259	Michelin	**1**	**69** dB	94,9	**4**	96,8	**3**	100,1	**3**	92,4	**3**	95,9	**1**	**96,0**	**3**	92,6	4
T1262	Vredestein	**2**	**70** dB	94,9	**3**	97,0	**4**	100,9	**5**	92,9	**5**			**96,4**	**5**	92,8	5
T1264	Bridgestone	**2**	**71** dB	95,7	**7**	97,1	**5**	99,5	**2**	93,3	**7**	96,1	**2**	**96,4**	**4**	93,1	6
T1267	Continental	**2**	**72** dB	95,3	**5**	97,4	**6**	100,6	**4**	93,3	**6**			**96,6**	**6**	93,2	7
T1268	Momo	**3**	**73** dB	96,6	**9**	98,7	**9**	101,6	**7**	94,5	**9**			**97,8**	**9**	95,0	9
T1269	Evergreen	**3**	**74** dB	95,3	**6**	97,7	**7**	101,7	**8**	92,5	**4**	97,1	**4**	**96,8**	**7**	92,5	3

When comparing the ranking for noise measurements under R117 test conditions with the one under LT' conditions one must conclude that they also differ.

The cause of this inconsistency will be analyzed in detail after analyzing all the results obtained also when tested in laboratory conditions (within WP4).

3.4 CPX SYSTEM COMPARISON

Tyre/road noise measurements on 2 Norwegian conventional pavements were performed by two CPX measuring systems, Polish and Norwegian, for comparison.

The GUT trailer is equipped with single test tyre, while the Norwegian trailer has two test tyres (see Figure 1 and Figure 2). Thus, for comparison of measured noise levels, the GUT trailer was driving somewhat off-center of the lane, to measure in the same wheel tracks as the Norwegian trailer. For safety reasons, the GUT trailer was centered for the right wheel track. Since the Norwegian trailer had two tyres of the same manufacturer, a direct comparison with GUT should only be done for the noise levels from the tyre mounted on the right side.

One should also remember that due to a failure of dynamic GPS device Racelogic (V-Box unit), responsible for actual speed control and recording, a GPS based speed measuring app on a mobile phone was used to control the vehicle speed as close as possible to 50 and 80 km/h. This introduced a measurement uncertainty which in this case was unavoidable. In the pre-processing tools (Excel sheets), a default value of 50 and 80 km/h has been applied.

The measured Sound Pressure Levels under the LT' test conditions, for two conventional pavements (MA11 and SMA16) in Norway recorded by Polish (GUT) and Norwegian (SINTEF) CPX system were presented in Figure 13 for 50 km/h and in Figure 14 for 80 km/h.

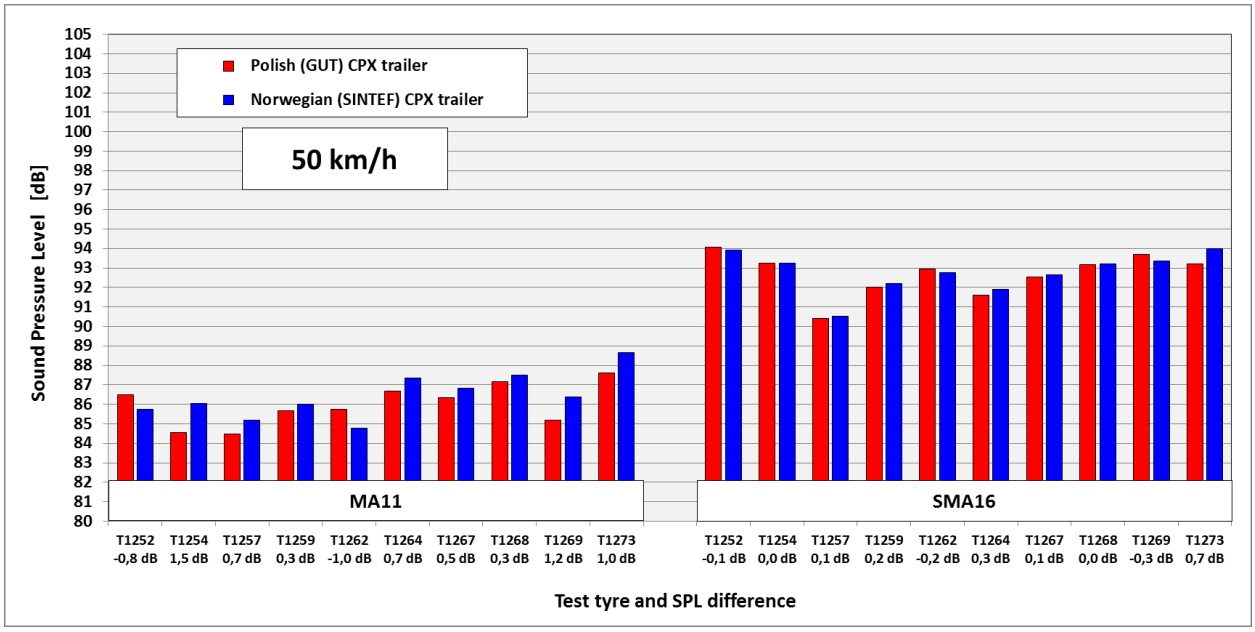

Figure 13. *CPX measuring system comparison for 50 km/h*

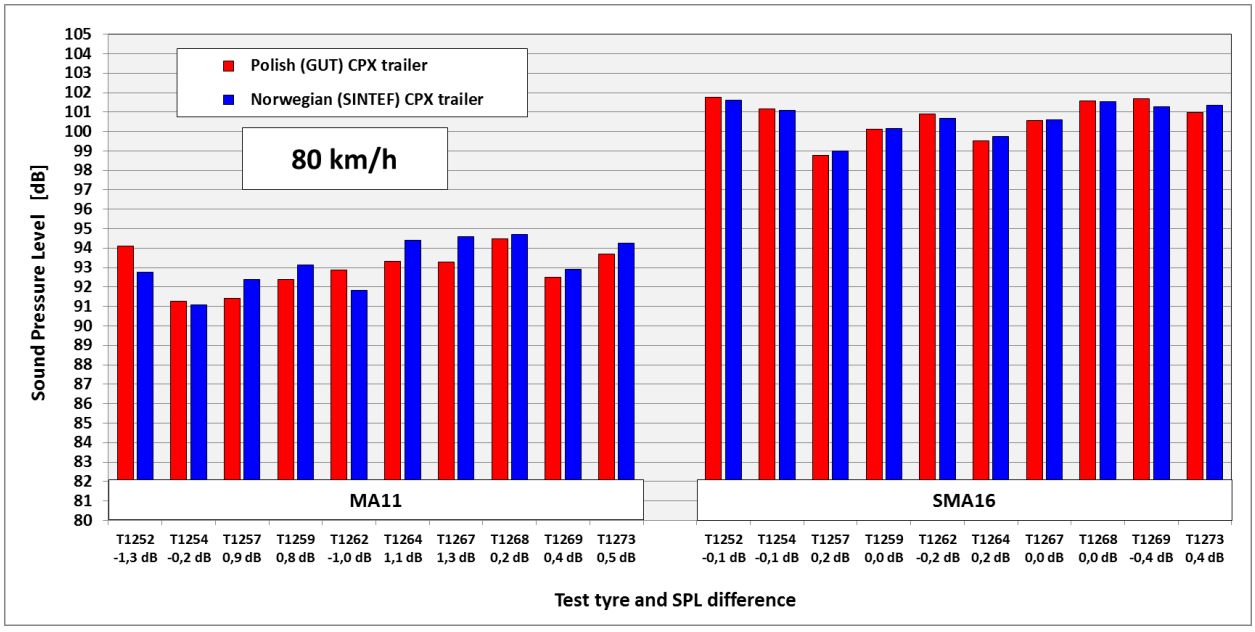

Figure 14. *CPX measuring system comparison for 80 km/h*

For the test speed of 50 km/h the differences between measuring systems, depending on a tested tyre, are from -1.0 dB up to 1.5 dB for MA11 pavement and from -0.3 dB up to 0.7 dB for SMA16 pavement. For 80 km/h the ranges are form -1.3 dB up to 1.3 dB and -0.4 dB up to 0.4 dB correspondingly. The presented levels are the average of driving directions "north" and "south". A separate analysis of the two directions showed that in the "south" direction on MA11 levels are much closer together than in the "north" direction. It seems that differences in the surface conditions on this road section is somewhat uneven for the two driving lanes.

4 CONCLUSIONS

The first part of tyre/road noise measurements on conventional pavements using the CPX method were performed in the summer of 2022 on 5 road sections: 2 in Norway and 3 in Poland. Tests were performed with tyre load and inflation pressure according to the values prescribed in the UNECE Regulation 117, designated "R117" conditions, as well as with a modified test condition designated "LT'". Measurements under R117 test conditions have been fully completed, while measurements under LT' conditions at EACC pavement in Poland have been performed for 5 of 11 tyres only, due to rain fall.

Noise measurements were performed using the GUT's CPX test trailer *Tiresonic Mk5* and, additionally on the two pavements in Norway, using the Norwegian trailer operated by SINTEF.

Based on the obtained results presented in this technical report the following conclusions can be formulated:

- the obtained differences in sound pressure levels for particular tyre when tested on different pavement were up to 10 dB (6-8 dB on the average) independent on test conditions (R117 or LT'),
- the smallest differences were observed for the Avon AV4 reference tyre – about 4-5 dB; when excluding both CPX reference tyres form this analysis, the smallest difference was 5.9 dB,
- although the spread in noise levels given on tyre labels was 8 dB, the maximum spread in measured noise levels on particular conventional pavement was between 3 and 4 dB (depending on test conditions and test speed),
- the average difference between R117 and LT' test conditions is, depending on a tyre, up to 1.0 dB for 50 km/h and 0.8 dB for 80 km/h,
- tyre ranking based on CPX noise measurements is totally different from the one based on noise values given on tyre labels,
- neither the quietest nor the loudest tyre according to its label corresponds to the noise levels measured for these tyres with the CPX method,
- the positions in the middle of the stake are also different
- differences in tyre ranking appear also between particular conventional pavements,
- the ranking on conventional pavements differs also from the ranking on ISO test tracks,
- tyre ranking for noise measurements under R117 test conditions differ from the one done under LT' conditions,
- differences between measuring systems (Polish and Norwegian) were from -1.3 dB up to 1.5 dB depending on a tested tyre, pavement and test speed.

Final conclusions will be formulated and presented here when all CPX noise tests (including laboratory measurements) are finished and full analysis of the obtained results is performed. This work will be done, according to the schedule, in 2023. Based on these findings, a new, improved tyre labelling procedure for passenger car tyre noise performance will be proposed. A procedure, that correlates much better with real road conditions than the present one.

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