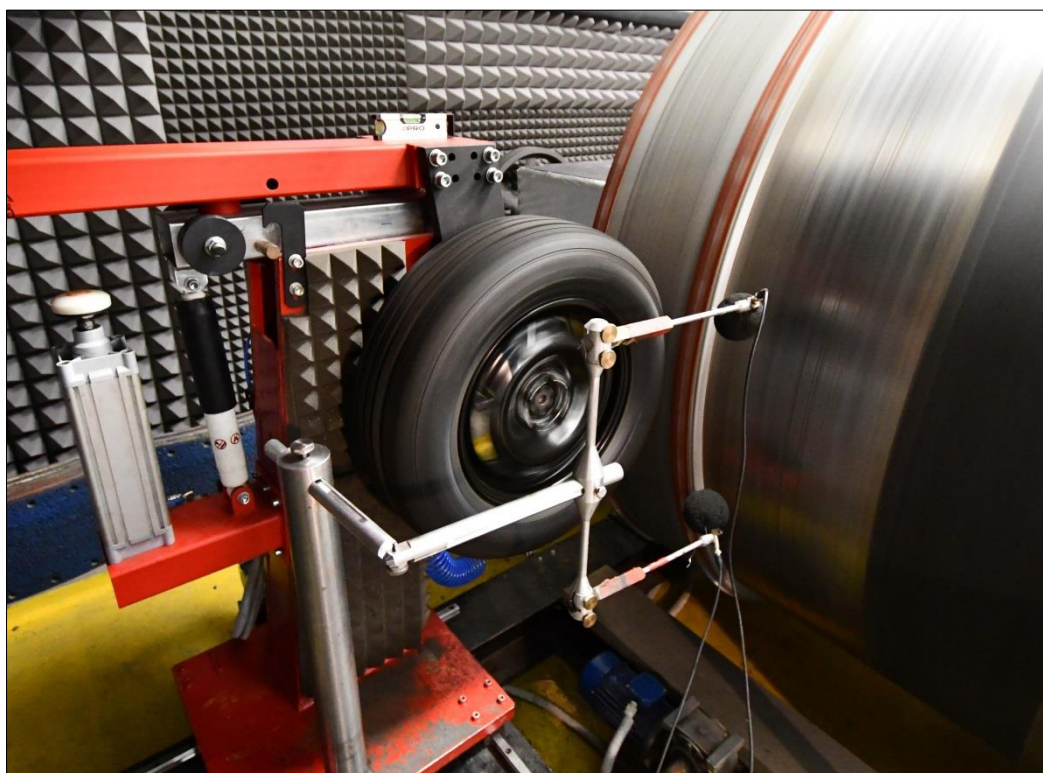


ELANORE Improvement of the EU tyre labelling system for noise and rolling resistance



Technical report from the test program of laboratory noise measurements

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	Work Package:	4	Development and evaluation of improved method of tyre/road noise measurements		
	Document type and number:	Technical Report, TR05-2-ELANORE-GUT-05-(2022)			
	Date, version and circulation:	30.12.2022	D4.1-1	Deliverable	
	File name:	TR05-2-ELANORE-GUT-05-(2022).docx			

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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*.

Laboratory drum measurements presented in this technical report were performed for the test tyres selected in WP1 (tyres that were dedicated mainly to noise tests) on road replica surfaces (including the new ones produced within WP3) with the main aim to estimate the correlation between road (CPX) and laboratory (drum) measurements.

2 MODERNIZATION OF THE ROADWHEEL FACILITY

The roadwheel facility utilized in all the tests presented in this technical report is located in the Car Tire Research Laboratory at Gdańsk University of Technology, Faculty of Mechanical Engineering and Ship Technology. It is equipped with an external drum of 2.0 m diameter covered with three different road replica surfaces: ISO (standard pavement according to the ISO 10844:1994 [2] - mandatory for tire/road noise tests proscribed in the Regulation 117), SMA8 (conventional Stone Mastic Asphalt with 8 mm aggregate size) and APS (very coarse Surface Dressing with an aggregate size of 11 mm). Additionally tests can be performed on a smooth steel surface. The roadwheel facility was presented in Fig. 1 and the road replicas were shown in Fig. 2.

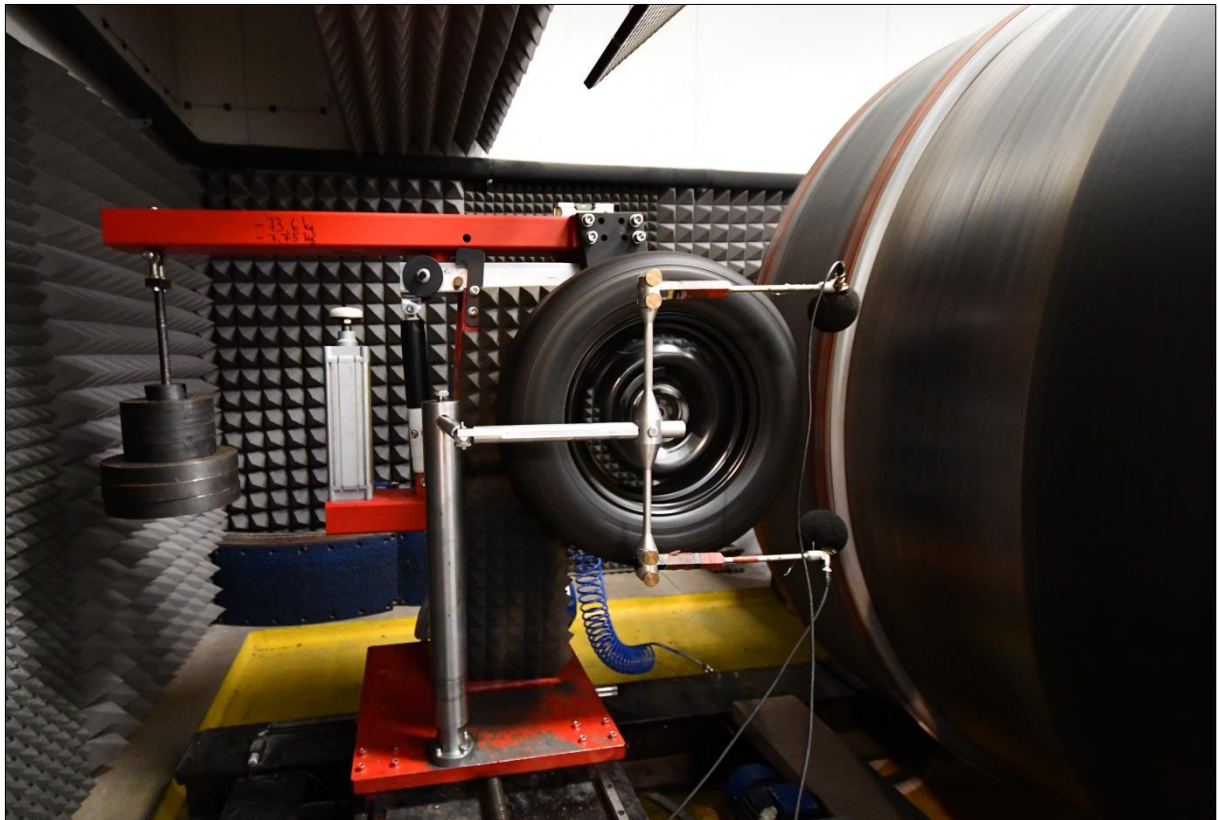


Fig. 1. Roadwheel facility in the Car Tire Research Laboratory at Gdańsk University of Technology



Fig. 2. Replica road surfaces used in noise measurements (from left: ISO, SMA8, APS)

Along with the modernization of the roadwheel facility performed in WP3 (in order to improve the precision of rolling resistance measurements), new sound-absorbing panels were purchased and installed surrounding the drum to improve the acoustics characteristic of the chamber in which the facility operates. A new microphone stand was also designed, manufactured and mounted. The introduced changes and improvements are visible in Fig. 1 and in the photo presented on the cover page of this technical report.

3 LABORATORY NOISE TESTING PROGRAM

Measurements were planned to be conducted under the same test conditions as were used in the Round Robin Test and when testing with the CPX method.

3.1 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. The selected tyres consist of 4 summer tyres, 3 winter and 2 all-season tyre.













Additionally, one set consisting of 4 pcs. of “Standard Reference Test Tyre” - SRTT (Uniroyal Tigerpaw) according to the ASTM F2493-14 was also purchased. Furthermore the standard reference tyre (Avon Supervan AV4), designated H1 according to the technical specification ISO/TS 11819-3:2017 [4] was used in the laboratory tests.

The details of all the selected and tested tyres were presented in Table 1. Designations and values given in bold mean the selected representative of tyre set when tested with CPX method.

Tab. 1. Description of the selected and tested tyres

Designation				Manufacturer	Tread pattern	Season	Tyre size	Load index	Speed rating	Remarks
T1252				Dębica	PRESTO UHP	Summer	215/55R17	94	W	
T1253	T1254	T1255	T1256	Yokohama	Advan Fleva V701	Summer	215/55R17	94	W	
T1257				Kenda	KR501	Winter	215/55R17	98	V	XL
T1258	T1259	T1260	T1261	Michelin	CrossClimate+	All season	215/55R17	98	W	XL
T1262				Vredestein	Ultrac Satin	Summer	215/55R17	98	W	XL
T1263	T1264	T1265	T1266	Bridgestone	Blizzak LM005	Winter	215/55R17	98	V	XL
T1267				Continental	AllSeasonContact	All season	215/55R17	98	H	XL
T1268				Momo	W-2 NORTH POLE	Winter	215/55R17	98	V	XL
T1269	T1270	T1271	T1272	Evergreen	EH23	Summer	215/55R17	98	V	XL
T1273	T1274	T1275	T1276	Uniroyal	Tiger Paw	SRTT	P225/60R16	97	S	
T1182				Avon	AV4	AAV4	195R14C	106/104	N	

Tab. 1. Description of the selected and tested tyres (cont.)

Designation				DOT				Tread rubber hardness							Noise level
T1252				3216				74				E	C		66 dB
T1253	T1254	T1255	T1256	3720	3720	3620	3720	68	68	70	71	C	A		67 dB
T1257				2420				61				E	C		68 dB
T1258	T1259	T1260	T1261	4920	4920	4920	4920	63	63	63	64	C	B		69 dB
T1262				1021				65				B	A		70 dB
T1263	T1264	T1265	T1266	4820	4820	4820	4720	63	64	64	67	C	A		71 dB
T1267				1121				63				A	B		72 dB
T1268				2520				67				E	C		73 dB
T1269	T1270	T1271	T1272	1620	1620	1620	1620	71	70	70	70	E	C		74 dB
T1273	T1274	T1275	T1276	4020	4020	4020	4020	66	66	66	66	-	-	-	-
T1182				4814				71				-	-	-	-

3.2 TEST CONDITIONS

Noise measurements were performed with tyre load and inflation pressure according to the values prescribed in the Regulation 117 as well as with modified test conditions.

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 are designated “R117” in this technical report.

In the modified conditions it was assumed that the tyre load and inflation pressure depend on the particular test vehicle, namely Skoda Superb. Thus the tyre load corresponds to the average load condition of this middle class vehicle: car net weight of 1590 kg (including the driver weighting 75 kg and 90 % of fuel) plus two passengers (each weighting 85 kg) and 80 kg of luggage. For the used test car the calculated tyre load was 460 kg. The inflation pressure should fulfill the vehicle manufacturer's requirements. The regular inflation pressure for this Skoda Superb was 230 kPa. These conditions are designated “LT” (light) in this technical report.

The measurements were performed with test speeds corresponding to speeds prescribed in the Regulation 117: 70, 75, 80, 85 and 90 km/h. Finally, the measurement results were extrapolated to the speed of 80 km/h. Additionally all tyres were tested with speeds of 40, 50 and 60 km/h. All tyres were run-in before measurements at a distance of 120 km.

The drum facility is located in thermostatic chamber allowing to maintain a constant temperature within the range of -15 °C to + 30 °C. During tests the temperature in the chamber was fixed to 20 °C.

4 LABORATORY NOISE MEASUREMENT RESULTS ON ISO REPLICA ROAD SURFACE

The first part of noise measurements presented in the current version of this technical report was conducted on drum covered with the ISO road replica surface under both: the R117 and *LT* test conditions. In the *R117* conditions tyre load and inflation pressure according to the UNECE Regulation No.117 (530 kg and 200 kPa) while in *LT* conditions they were 460 kg and 230 kPa correspondingly.

Additionally the tyre/road noise levels of laboratory measurements at test speeds of 70, 75, 80, 85 and 90 km/h, for the comparison with the results obtained during Round Robin Test, were extrapolated to the reference speed of 80 km/h by formulae of speed correction given in the Annex of the ISO 11819-2:2017 [3] standard. The levels were denoted L_{RD} .

4.1 NOISE LEVELS

The results of noise measurements, A-weighted sound pressure levels of the average of front and rear microphones, for *R117* test conditions were presented in Table 2 and, for the test speeds of 50 and 80 km/h, Results obtained under *LT* test conditions were shown in Fig. 3. Table 3 and Fig. 4 correspondingly.

Tab. 2. Noise levels of tested tyres on ISO road replica surface under the R117 test conditions

Tyre	Sound Pressure Level in dB(A) at a test speed of:								L_{RD} 80 km/h	Label noise bar	Label noise level
	40 km/h	50 km/h	60 km/h	70 km/h	75 km/h	80 km/h	85 km/h	90 km/h			
T1252	84,6	88,5	91,2	93,6	94,7	96,5	97,2	98,0	96,0	1	66 dB
T1253	84,8	89,0	91,5	94,1	95,1	97,1	97,9	98,9	96,7	1	67 dB
T1254	85,5	89,3	92,2	94,7	95,8	97,5	98,6	99,3	97,2	1	67 dB
T1255	85,6	89,2	92,1	94,4	95,4	97,0	97,8	98,6	96,7	1	67 dB
T1256	86,6	90,5	93,6	95,9	96,9	98,0	99,2	100,2	98,1	1	67 dB
T1257	87,3	90,9	93,9	96,1	98,1	99,7	100,4	101,3	99,2	1	68 dB
T1258	88,7	92,4	95,2	97,7	99,2	100,4	101,8	102,5	100,4	1	69 dB
T1259	88,0	91,9	95,1	97,5	98,8	100,4	101,7	102,4	100,2	1	69 dB
T1260	88,4	92,2	94,9	97,5	99,0	100,4	101,4	102,1	100,1	1	69 dB
T1261	89,1	92,4	95,4	97,7	98,9	100,4	101,7	102,2	100,2	1	69 dB
T1262	88,6	92,1	95,4	97,4	99,0	100,5	101,9	102,7	100,3	2	70 dB
T1263	86,1	89,9	92,5	94,2	95,8	96,8	97,9	98,9	96,8	2	71 dB
T1264	87,2	90,9	93,5	95,6	97,0	97,9	98,9	99,9	97,9	2	71 dB
T1265	86,8	90,4	93,1	95,3	96,8	97,6	98,6	99,7	97,7	2	71 dB
T1266	87,5	91,0	93,5	94,3	96,7	97,8	99,2	100,1	97,7	2	71 dB
T1267	88,4	92,5	96,0	98,0	100,2	101,2	103,0	103,7	101,3	2	72 dB
T1268	88,6	92,8	96,0	98,2	99,8	101,3	102,2	103,1	101,0	3	73 dB
T1269	87,2	90,8	93,7	96,0	97,6	99,2	100,7	101,2	99,0	3	74 dB
T1270	87,8	90,5	93,4	95,6	97,4	98,9	100,3	100,8	98,6	3	74 dB
T1271	87,2	90,7	93,7	95,9	97,5	99,2	100,5	101,0	98,9	3	74 dB
T1272	87,1	90,4	93,3	95,6	97,3	99,1	100,4	101,0	98,7	3	74 dB
T1273	88,7	92,6	95,0	97,0	97,7	99,5	100,3	101,3	99,2	-	-
T1274	89,8	93,4	95,8	98,2	99,7	100,5	101,2	102,3	100,4	-	-
T1275	89,0	92,7	95,0	97,1	98,5	99,6	100,3	101,4	99,4	-	-
T1276	88,8	92,7	95,3	97,8	99,4	100,3	101,0	102,3	100,2	-	-
T1182	90,1	93,7	96,6	99,1	100,4	101,6	102,5	103,1	101,4	-	-

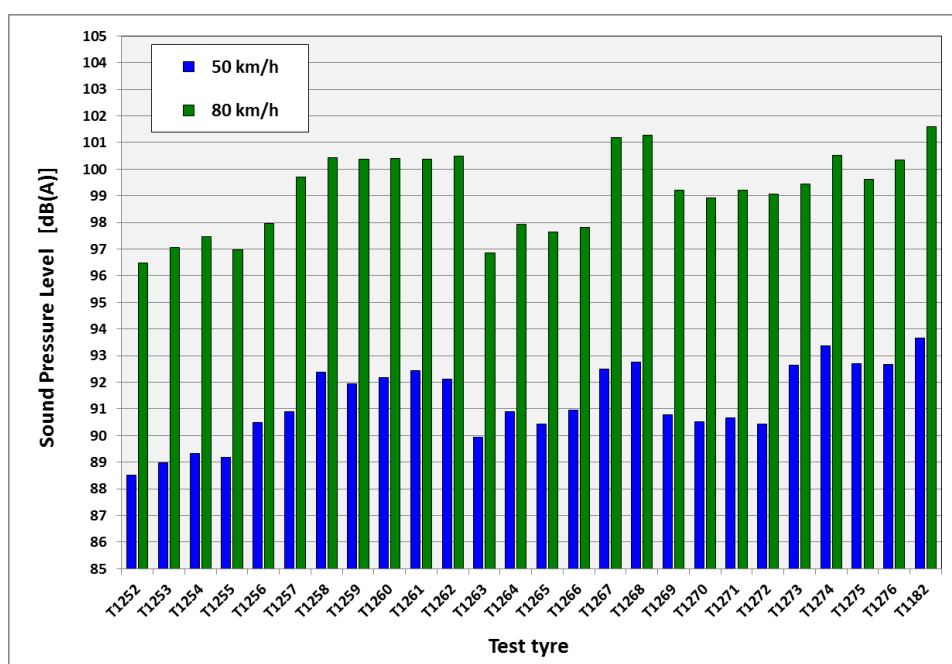


Fig. 3. Noise levels of tested tyres on ISO road replica surface under the R117 test conditions for the speeds of 50 and 80 km/h

Tab. 3. Noise levels of tested tyres on ISO road replica surface under the LT test conditions

Tyre	Sound Pressure Level in dB(A) at a test speed of:								L _{RD}	Label noise bar	Label noise level
	40 km/h	50 km/h	60 km/h	70 km/h	75 km/h	80 km/h	85 km/h	90 km/h			
T1252	86,5	90,1	92,7	94,6	95,9	96,9	98,1	99,3	97,0	1	66 dB
T1253	85,2	89,1	91,4	93,7	95,0	96,1	97,0	98,6	96,1	1	67 dB
T1254	85,2	89,2	91,7	94,3	95,4	96,3	97,5	98,9	96,5	1	67 dB
T1255	85,1	88,9	91,4	93,8	94,8	95,9	96,8	98,5	96,0	1	67 dB
T1256	85,5	89,6	91,8	94,4	95,6	96,3	97,6	98,8	96,6	1	67 dB
T1257	86,1	90,5	93,9	96,4	97,7	99,2	100,8	102,2	99,3	1	68 dB
T1258	86,5	90,5	93,5	96,2	98,0	99,1	100,5	101,9	99,2	1	69 dB
T1259	88,0	91,7	94,6	97,3	98,7	99,4	100,8	102,0	99,7	1	69 dB
T1260	86,4	90,7	93,5	96,4	98,1	99,3	100,7	102,1	99,4	1	69 dB
T1261	87,5	91,4	94,4	97,0	98,5	99,2	100,7	101,8	99,5	1	69 dB
T1262	87,8	91,3	94,0	96,7	97,8	98,7	100,2	101,7	99,1	2	70 dB
T1263	86,7	90,2	92,9	94,9	95,9	97,2	98,5	99,5	97,2	2	71 dB
T1264	88,6	92,2	95,0	97,2	98,2	99,4	100,5	101,6	99,4	2	71 dB
T1265	88,4	91,9	94,6	96,9	97,9	99,0	100,3	101,2	99,1	2	71 dB
T1266	87,8	91,2	93,8	95,9	96,8	97,8	98,8	100,1	97,9	2	71 dB
T1267	90,7	94,2	96,4	99,0	100,0	100,8	102,0	103,2	101,0	2	72 dB
T1268	88,9	93,0	95,9	98,5	99,7	100,6	101,9	103,1	100,8	3	73 dB
T1269	86,3	90,4	92,9	95,5	97,0	97,7	99,3	100,9	98,1	3	74 dB
T1270	87,5	91,3	93,8	96,2	97,7	98,4	100,0	101,5	98,8	3	74 dB
T1271	86,8	90,8	93,2	95,7	97,3	98,1	99,6	101,1	98,4	3	74 dB
T1272	86,9	91,0	93,5	95,9	97,5	98,2	99,8	101,3	98,6	3	74 dB
T1273	87,7	92,0	94,4	96,7	97,9	99,2	100,2	101,0	99,1	-	-
T1274	89,3	92,7	95,1	97,5	98,8	99,8	101,0	101,8	99,8	-	-
T1275	89,1	92,6	95,0	97,1	98,3	99,3	100,1	100,8	99,2	-	-
T1276	88,4	92,2	94,4	96,9	98,1	99,4	100,6	101,6	99,4	-	-
T1182	90,0	93,6	96,4	99,1	100,3	101,5	102,3	102,9	101,3	-	-

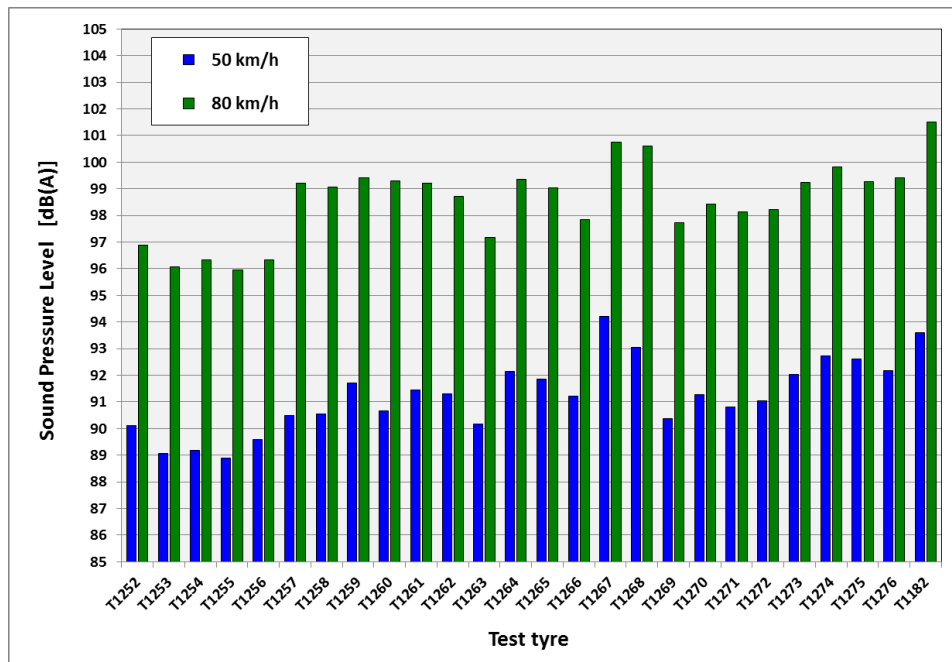


Fig. 4. Noise levels of tested tyres on ISO road replica surface under the LT test conditions for the speeds of 50 and 80 km/h

4.2 NOISE LEVEL DIFFERENCES UNDER BOTH TEST CONDITIONS

Differences in the measured sound pressure levels under two different test conditions are shown in Table 4. The values were obtained subtracting the SPLs under *LT* test conditions from SPLs from *R117* ones.

Tab. 4. Noise level differences under both test conditions

Tyre	Label noise bar	Label noise level	Difference in Sound Pressure Level in dB(A) at load of 530 kg vs. 460 kg:								L _{RD} 80 km/h	Average difference
			40 km/h	50 km/h	60 km/h	70 km/h	75 km/h	80 km/h	85 km/h	90 km/h		
T1252	1	66 dB	-1,8	-1,6	-1,4	-1,0	-1,2	-0,4	-0,9	-1,3	-1,0	-1,2
T1253	1	67 dB	-0,5	-0,1	0,1	0,4	0,1	1,0	0,9	0,3	0,5	0,3
T1254	1	67 dB	0,3	0,1	0,5	0,4	0,4	1,1	1,1	0,4	0,7	0,6
T1255	1	67 dB	0,4	0,3	0,7	0,7	0,6	1,0	1,0	0,1	0,7	0,6
T1256	1	67 dB	1,1	0,9	1,8	1,5	1,3	1,6	1,6	1,3	1,5	1,4
T1257	1	68 dB	1,2	0,4	0,0	-0,3	0,4	0,5	-0,5	-0,9	-0,2	0,1
T1258	1	69 dB	2,2	1,8	1,7	1,5	1,1	1,4	1,2	0,5	1,1	1,4
T1259	1	69 dB	0,0	0,2	0,5	0,2	0,1	1,0	0,9	0,4	0,5	0,4
T1260	1	69 dB	2,0	1,5	1,3	1,2	0,9	1,1	0,7	0,0	0,8	1,0
T1261	1	69 dB	1,6	1,0	1,0	0,7	0,4	1,2	0,9	0,4	0,7	0,9
T1262	2	70 dB	0,7	0,8	1,5	0,7	1,2	1,8	1,7	1,0	1,3	1,2
T1263	2	71 dB	-0,5	-0,2	-0,3	-0,6	-0,1	-0,3	-0,6	-0,5	-0,4	-0,4
T1264	2	71 dB	-1,4	-1,2	-1,5	-1,6	-1,2	-1,4	-1,6	-1,7	-1,5	-1,5
T1265	2	71 dB	-1,6	-1,4	-1,5	-1,6	-1,1	-1,4	-1,6	-1,5	-1,4	-1,5
T1266	2	71 dB	-0,3	-0,3	-0,3	-1,5	-0,1	0,0	0,4	0,0	-0,3	-0,3
T1267	2	72 dB	-2,3	-1,7	-0,4	-1,0	0,2	0,4	1,1	0,5	0,2	-0,3
T1268	3	73 dB	-0,3	-0,3	0,1	-0,2	0,2	0,7	0,3	0,0	0,2	0,1
T1269	3	74 dB	0,9	0,4	0,7	0,5	0,6	1,5	1,3	0,2	0,8	0,8
T1270	3	74 dB	0,3	-0,8	-0,4	-0,6	-0,3	0,5	0,3	-0,7	-0,2	-0,2
T1271	3	74 dB	0,5	-0,2	0,4	0,3	0,2	1,1	0,9	-0,1	0,5	0,4
T1272	3	74 dB	0,2	-0,6	-0,2	-0,3	-0,1	0,9	0,5	-0,3	0,1	0,0
T1273	-	-	1,0	0,6	0,7	0,3	-0,2	0,2	0,1	0,3	0,2	0,4
T1274	-	-	0,5	0,6	0,7	0,8	0,9	0,7	0,3	0,5	0,6	0,6
T1275	-	-	-0,1	0,1	0,0	0,0	0,2	0,4	0,2	0,6	0,3	0,2
T1276	-	-	0,4	0,5	0,9	0,8	1,4	0,9	0,4	0,6	0,8	0,7
T1182	-	-	0,2	0,1	0,2	0,0	0,1	0,1	0,3	0,2	0,1	0,1

One can observe that the calculated SPLs differences between both test conditions are rather small and depending on test tyre can be from 0 dB up 1.5 dB. The average difference is only 0.2 dB and the average absolute difference is 0.6 dB.

4.3 TYRE RANKING

It was expected that the tyre ranking according the noise value given on the tyre label corresponds with the ranking according to measured sound levels during laboratory measurements. The L_{RD} values, averaged over tyres of the same brand when 4 tyres were tested, were used for this comparison. The obtained results were presented in Table 4.

Tab. 4. Tyre ranking comparison

Manufacturer	Tread pattern	Season	Tyre label		Tyre load: 530 kg		Tyre load: 460 kg	
			Noise bar	Noise level	SPL [dB(A)]	Position in ranking	SPL [dB(A)]	Position in ranking
Dębica	PRESTO UHP	Summer	1	66 dB	96,0	1	97,0	2
Yokohama	Advan Fleva V701	Summer	1	67 dB	97,2	2	96,3	1
Kenda	KR501	Winter	1	68 dB	99,2	5	99,3	6
Michelin	CrossClimate+	All season	1	69 dB	100,2	6	99,4	7
Vredestein	Ultrac Satin	Summer	2	70 dB	100,3	7	99,1	5
Bridgestone	Blizzak LM005	Winter	2	71 dB	97,5	3	98,4	3
Continental	AllSeasonContact	All season	2	72 dB	101,3	9	101,0	9
Momo	W-2 NORTH POLE	Winter	3	73 dB	101,0	8	100,8	8
Evergreen	EH23	Summer	3	74 dB	98,8	4	98,5	4

One can easily observe that the tyre ranking based on laboratory 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 in the laboratory tests. The positions in the middle of the stake are also different. Also the tyre ranking obtained for the two test conditions, *R117* and *LT*, differs. The cause of this inconsistency will be analyzed in detail after analyzing the results obtained during the Round Robin Test and when tested the tyres with the CPX method. But please also take into account that in few cases the differences between measured noise levels of tested tyres are very small, 0.1 - 0.3 dB, within the measurement error.

5 LABORATORY NOISE MEASUREMENT RESULTS ON SMA8 REPLICA ROAD SURFACE

All noise tests on SMA8 replica road surface have been finalized in late December 2022. Measurements were performed for 2 test conditions written in detail in chapter 3.2. It was no time by the end of 2022 to perform any evaluation of the measurement data acquired on this

replica road surface. All analysis of the obtained results will be performed in 2023 (according to the schedule).

6 LABORATORY NOISE MEASUREMENT RESULTS ON APS REPLICA ROAD SURFACE

Noise measurements on APS replica road surface are planned to be performed in 2023 only for a part of all the selected tyres described in chapter 3.1. From each set of 4 nominally the same tyres, 3 tyres will be excluded. The remaining 11 tyres (of which designations and values are given in bold in Table 1) are the same tyres that were measured using the CPX method on trafficked roads with conventional pavements. These tyres will be measured on APS replica road surface with 2 test conditions: *R117* and *LT*.

7 CONCLUSIONS

Preliminary conclusions from the laboratory noise measurements performed on ISO replica road surface are presented in chapter 4. Final conclusions will be formulated and presented here when all laboratory noise tests are finished and full analysis of the obtained results is performed. This work will be done, according to the schedule, in 2023.

REFERENCES

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- [3] International Organization for Standardization (ISO): *Acoustics – Method for measuring the influence of road surfaces on traffic noise – Part 2: The close proximity method*, ISO 11819-2:2017, Geneva, Switzerland, 2017
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