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ELANORE Project – final conclusions and recommendations

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Technology for a better society

1. Introduction

- In November 2023, the main results from the noise part of ELANORE was presented to TF VS (See GRBP-TFVS-14-03).
- In this presentation, we will summarize some parts of the results, mainly based on the CPX and drum measurements.
- The most crucial issues connected to the test procedure in Reg.117 are evaluated.
- The main conclusions and proposals for improvements of the noise labelling procedure are presented.

2. The ELANORE project - short summary

- The "EU tyre LAbelling system for NOise and rolling RESistance" is a joint international project between Gdansk University of Technology (GUT, PL), SINTEF (N) and EKKOM (PL).
- Project period: 2020-2024. Budget: Approx. 1.2 mill EURO.
- **Main objectives: To improve the efficiency of the EU tyre label both concerning rolling resistance and noise.**

CPB – Controlled Pass-by method

Specified in: **ISO 13325:2019 *„Tyres — Coast-by methods for measurement of tyre-to-road sound emission"***

Road measurements of the noise of a coasting vehicle.

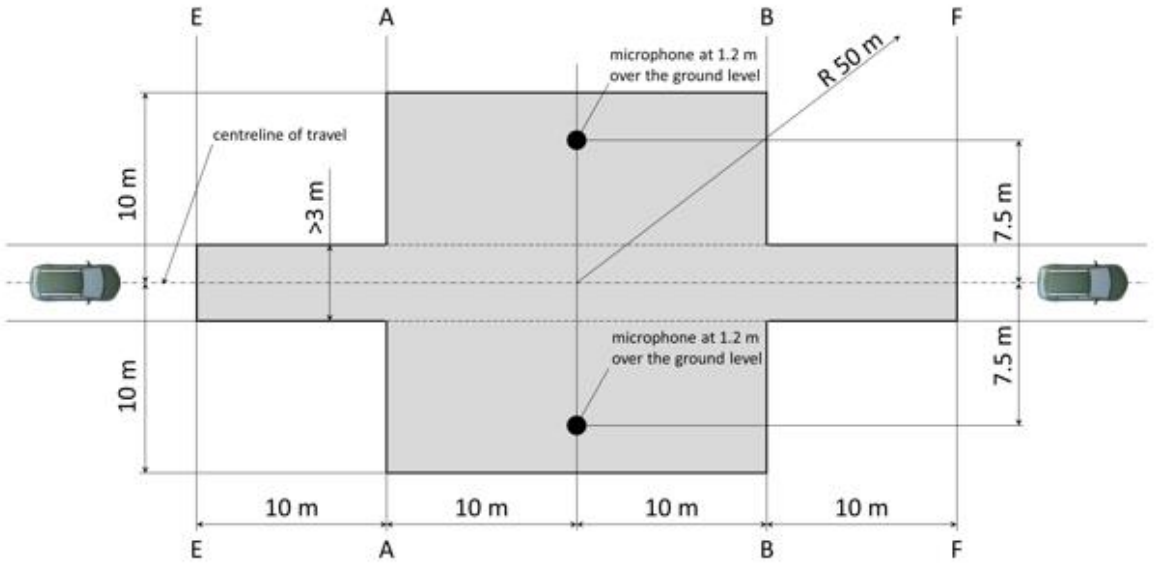
All test conditions strictly defined in the above ISO standard.

Test area with no large acoustically reflective objects within a radius of 50 m.

Test surface meets the requirements of ISO 10844:2014.

Microphones located on both sides of the test track

- in a distance from the centreline of 7.5 m,
- at a height of 1.2 m.



CPX – Close ProXimity method

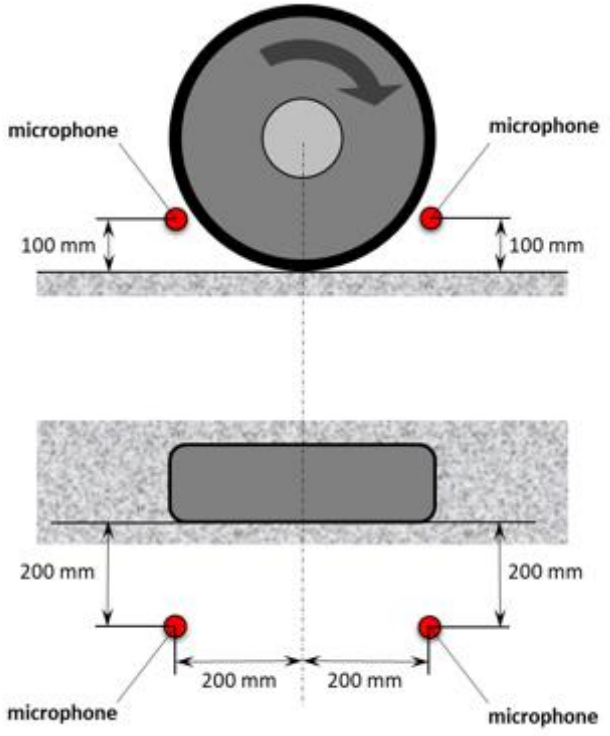
Specified in: ISO 11819-2:2017 *„Acoustics — Measurement of the influence of road surfaces on traffic noise — Part 2: The close-proximity method"*

Road measurements of tyre/road noise only using a special test trailer or on a test vehicle.

All test conditions strictly defined in the above ISO standard.

Microphones positioned close to the test tyre.

Test tyre load is limited by the construction parameters of the trailer.



DRUM – Laboratory drum method

Based on: Close proximity method (CPX)

Laboratory measurements of tyre/road noise on a roadwheel facility equipped with replica road surface.

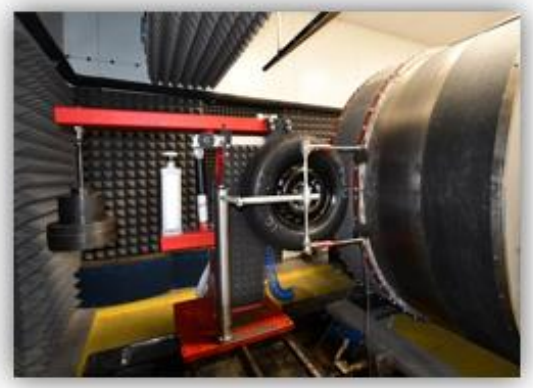
Drum can be situated inside a climate-controlled chamber (– 15 °C to + 30 °C).

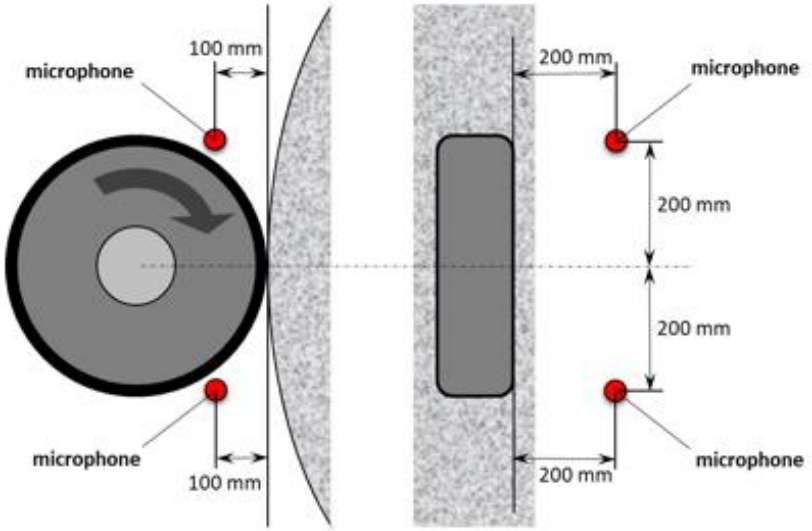
Replicas of road surfaces can be attached to the drum of the roadwheel facility.

Microphones positioned close to the test tyre.

All test conditions adopted from the CPX method.

Wide range of test conditions (tyre load, inflation pressure, speed).





Selection of test tyres

- **9 tyre types** covering the range of EU label noise values **from 66 dB up to 74 dB** with 1 dB step, labelled **1 to 3 noise bars**, consisted of **4 summer** tyres, **3 winter** and **2 all-season** tyres
- **2 reference tyres** according to the ISO/TS 11819-3:2017 - the "Standard Reference Test Tyre" SRTT Uniroyal Tigerpaw (***P1***) and Avon Supervan AV4 (***H1***)

Manufacturer	Tread pattern	Season	Tyre size	Load index	Speed rating	Remarks				Noise level	Tests performed		
Dębica	PRESTO UHP	Summer	215/55R17	94	W		E	C	A	66 dB		CPX	DRUM
Yokohama	Advan Fleva V701	Summer	215/55R17	94	W		C	A	A	67 dB	CPB	CPX	DRUM
Kenda	KR501	Winter	215/55R17	98	V	XL	E	C	A	68 dB		CPX	DRUM
Michelin	CrossClimate+	All season	215/55R17	98	W	XL	C	B	A	69 dB	CPB	CPX	DRUM
Vredestein	Ultrac Satin	Summer	215/55R17	98	W	XL	B	A	B	70 dB		CPX	DRUM
Bridgestone	Blizzak LM005	Winter	215/55R17	98	V	XL	C	A	B	71 dB	CPB	CPX	DRUM
Continental	AllSeasonContact	All season	215/55R17	98	H	XL	A	B	B	72 dB		CPX	DRUM
Momo	W-2 NORTH POLE	Winter	215/55R17	98	V	XL	E	C	C	73 dB		CPX	DRUM
Evergreen	EH23	Summer	215/55R17	98	V	XL	E	C	C	74 dB	CPB	CPX	DRUM
Uniroyal	Tiger Paw	SRTT	P225/60R16	97	S		-	-	-	-	CPB	CPX	DRUM
Avon	Supervan AV4	AAV4	195R14C	106/104	N		-	-	-	-		CPX	DRUM

Selection of ISO tracks, conventional pavements and replika road surfaces

4 ISO test tracks (CPB and CPX measurements):

- 3 in Germany: **ISO reference surface**
- 1 in Sweden: **ISO reference surface**

5 test sites for CPB and CPX measurements:

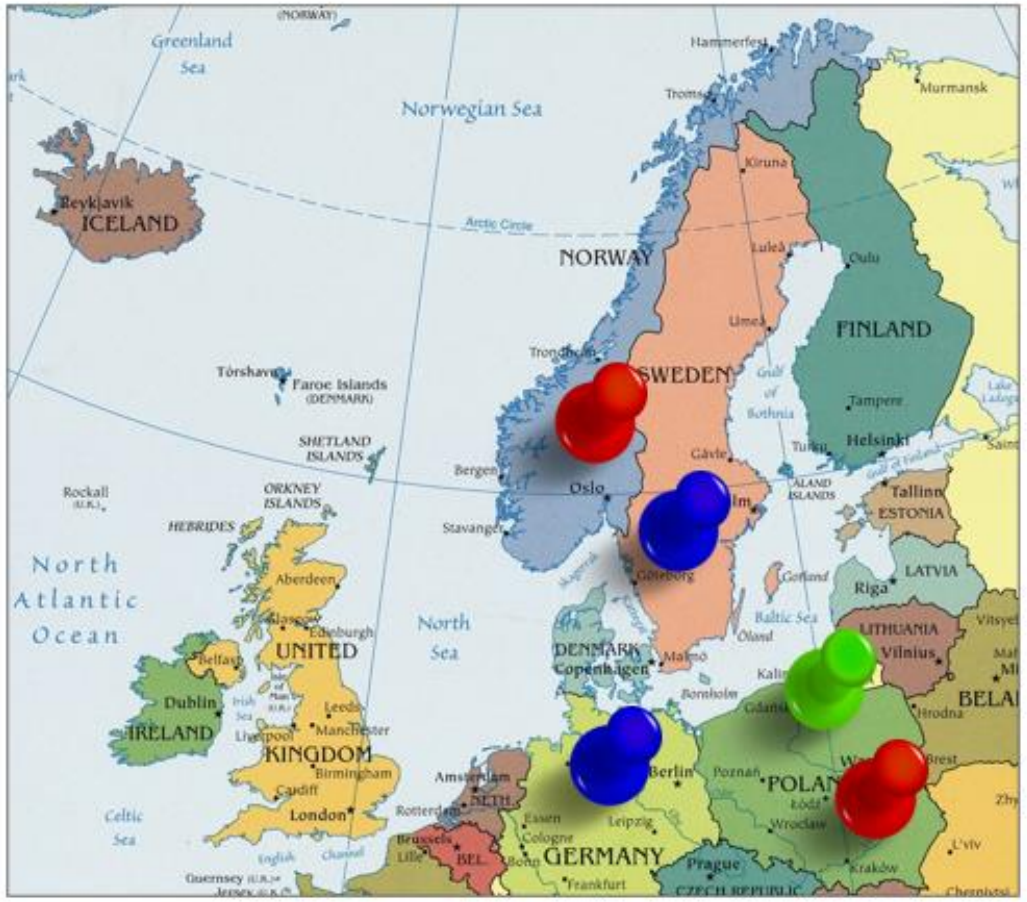
- 3 in Poland: **SMA8, SMA11** and **EACC8**
- 2 in Norway: **MA11** and **SMA16**

2 test sites for CPX tests only:

- 2 in Poland: **DAC11** and **BBTM8**

3 replica road surfaces for DRUM tests only:

- 3 in Poland: **ISO, SMA8** and **DAC16**



Test conditions

Noise tests within the ELANORE project were performed under the following test conditions:

Tests	Test conditions	Designation	Test speeds	Tyre load	Inflation pressure
CPB	According to Reg. 117	R117	40, 50, 60 km/h and at least 8 runs between 70 and 90 km/h	530 kg	200 kPa
	Light test conditions	LT		460 kg	230 kPa
CPX	According to Reg. 117	R117	50 and 80 km/h	530 kg	200 kPa
	Light test conditions	LT		460 kg	230 kPa
	Reduced light test conditions	LT'		320 kg	230 kPa
DRUM	According to Reg. 117	R117	40, **50**, 60, 70, 75, **80**, 85 and 90 km/h	530 kg	200 kPa
	Light test conditions	LT		460 kg	230 kPa

Representativeness of ISO surface – CPX method

R117 conditions - 80 km/h

Tyre	Label		CPX method, R117 conditions - 80 km/h																				
			ISO			MA11			SMA8			SMA11			SMA16			EACC8			Average of conventional pavements		
	Value	Ranking position	SPL [dB]	R.117 value	Ranking position	SPL [dB]	R.117 value	Ranking position	SPL [dB]	R.117 value	Ranking position	SPL [dB]	R.117 value	Ranking position	SPL [dB]	R.117 value	Ranking position	SPL [dB]	R.117 value	Ranking position	SPL [dB]	R.117 value	Ranking position
Debica	**66** dB	Spread: **8 dB**	93,3	92	Spread: **4 dB**	93,8	92	Spread: **4 dB**	96,0	95	Spread: **3 dB**	98,4	97	Spread: **3 dB**	102,3	101	Spread: **3 dB**	97,9	96	Spread: **3 dB**	97,7	96	Spread: **3 dB**
Yokohama	**67** dB		91,4	90		91,9	90		94,5	93		97,6	96		102,2	101		97,2	96		96,7	95	
Kenda	**68** dB		91,9	90		91,7	90		93,9	92		96,1	95		99,6	98		95,9	94		95,4	94	
Michelin	**69** dB		92,4	91		92,8	91		94,7	93		97,3	96		100,7	99		96,5	95		96,4	95	
Vredestein	**70** dB		92,7	91		92,9	91		94,5	93		97,3	96		101,5	100		96,8	95		96,6	95	
Bridgestone	**71** dB		92,5	91		93,4	92		95,5	94		97,8	96		100,6	99		96,8	95		96,8	95	
Continental	**72** dB		93,4	92		94,6	93		96,1	95		98,5	97		101,3	100		97,7	96		97,7	96	
Momo	**73** dB		95,5	94		95,1	94		97,0	95		99,2	98		102,5	101		98,8	97		98,5	97	
Evergreen	**74** dB		92,6	91		92,6	91		95,3	94		98,1	97		102,6	101		97,6	96		97,2	96	
Uniroyal SRTT	-	-	94,4			94,4			96,0			98,6			102,4			97,9			97,9		
Avon AV4	-	-	96,5			96,2			97,6			98,6			101,0			98,1			98,3		
min		9	91,4	90	4	91,7	90	5	93,9	92	4	96,1	95	4	99,6	98	4	95,9	94	4	95,4	94	4
max			96,5	94		96,2	94		97,6	95		99,2	98		102,6	101		98,8	97		98,5	97	
avg			**93,3**			**93,6**			**95,5**			**97,9**			**101,5**			**97,4**			**97,2**		
Spread of tyres 1-9	*8*		*4,1*	*4*		*3,4*	*4*		*3,1*	*3*		*3,2*	*3*		*3,0*	*3*		*2,9*	*3*		*3,1*	*3*	

Representativeness of ISO surface – CPX method

Pavement ranking – R117 test conditions

Tyre	Label		CPX method, R117 conditions													
			ISO		MA11		SMA8		SMA11		SMA16		EACC8		Average pavement	
	Value	Ranking position	50 km/h	80 km/h	50 km/h	80 km/h	50 km/h	80 km/h	50 km/h	80 km/h	50 km/h	80 km/h	50 km/h	80 km/h	50 km/h	80 km/h
Dębica	**66** dB	**1**	**3**	**3**	**3**	**3**	**3**	**4**	**3**	**3**	**4**	**4**	**3**	**3**	**3**	**3**
Yokohama	**67** dB	**2**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**4**	**4**	**2**	**3**	**2**	**2**
Kenda	**68** dB	**3**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Michelin	**69** dB	**4**	**2**	**2**	**1**	**2**	**1**	**2**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**
Vredestein	**70** dB	**5**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**3**	**3**	**2**	**2**	**2**	**2**
Bridgestone	**71** dB	**6**	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**3**	**2**
Continental	**72** dB	**7**	**3**	**3**	**3**	**4**	**2**	**4**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
Momo	**73** dB	**8**	**4**	**4**	**3**	**5**	**3**	**4**	**4**	**4**	**4**	**4**	**3**	**4**	**4**	**4**
Evergreen	**74** dB	**9**	**2**	**2**	**1**	**2**	**2**	**3**	**3**	**3**	**4**	**4**	**3**	**3**	**3**	**3**
Number of positions in ranking		***9***	***4***	***4***	***3***	***5***	***3***	***4***	***4***	***4***	***4***	***4***	***3***	***4***	***4***	***4***

Representativeness of ISO surface – DRUM method

Pavement ranking – R117 test conditions

Tyre	Label		DRUM method, R117 conditions							
			ISO		SMA8		DAC16		Average pavement	
	Value	Ranking position	50 km/h	80 km/h	50 km/h	80 km/h	50 km/h	80 km/h	50 km/h	80 km/h
Dębica	**66** dB	**1**	1	1	2	2	3	2	3	2
Yokohama	**67** dB	**2**	2	2	1	1	3	3	2	3
Kenda	**68** dB	**3**	3	4	1	1	2	2	2	2
Michelin	**69** dB	**4**	4	5	2	2	2	2	2	3
Vredestein	**70** dB	**5**	4	5	2	1	1	1	1	1
Bridgestone	**71** dB	**6**	3	2	3	2	3	2	3	3
Continental	**72** dB	**7**	5	6	4	3	2	2	3	3
Momo	**73** dB	**8**	5	6	4	4	3	4	3	4
Evergreen	**74** dB	**9**	3	3	2	2	2	3	2	3
Number of positions in ranking		***9***	***5***	***6***	***4***	***4***	***3***	***4***	***3***	***4***

Representativeness of ISO surface

Conclusions:

- Both test methods, namely CPX and DRUM, are comparable
- There is **no correlation** between the **Noise Label values** and the **measured noise levels on ISO reference surface**
- There is **no correlation** between the **Noise Label values** and the **measured noise levels on conventional pavements**
- There **is a general correlation** between the **measured noise levels** on **ISO reference surface** and on **conventional pavements**
- The **spread of measured noise levels** for the tested tyres is **less than half** of the **spread of their labelled values**
- The test **speed has a very minor or no effect on the ranking** of the tested tyres
- The obtained **differences in sound pressure levels for particular tyre** when tested on **different pavements were up to 10 dB** (**6-8 dB on the average**) independent on test conditions (R117 or LT'),

Reg.117 procedure – the most crucial issues

Problems and issues that arose during tyre testing in accordance with the Reg.117 procedure:

- The very smooth textured **ISO reference surface** (ISO 10844:2014) **is not fully representative** to the conventional pavements used on roads in real conditions.
- Why are tests carried out at speeds between 70 and 90 km/h only? The **speed limit** in the city is usually **50 km/h** and **the most important thing is to control vehicle noise within the city area**, not outside the city.
- **It is at least strange to test winter and all-season tyres at the reference temperature of 20 °C.**
  The temperature influence is of about -1 dB / 10 °C.
- It would be **easier to use air temperature** rather than road surface temperature as a reference.
- The tyre load and inflation pressure according to Reg.117 do not correspond to the values provided by the vehicle manufacturer (our test vehicle was almost **fully loaded and tyres were highly underinflated** at the same time).
- It was not easy to load the test vehicle according to Reg.117 requirements because of the vehicle suspension construction and its properties. It was a problem with a heavy driver influencing the proper weight distribution.
- It was **impossible to coast the vehicle** during tests. In modern vehicles **engine cannot be switched off** when vehicle is moving (car electronics do not allow, steering wheel locks, brakes have no assist, etc.).

Improved Tyre Labelling Procedure for noise

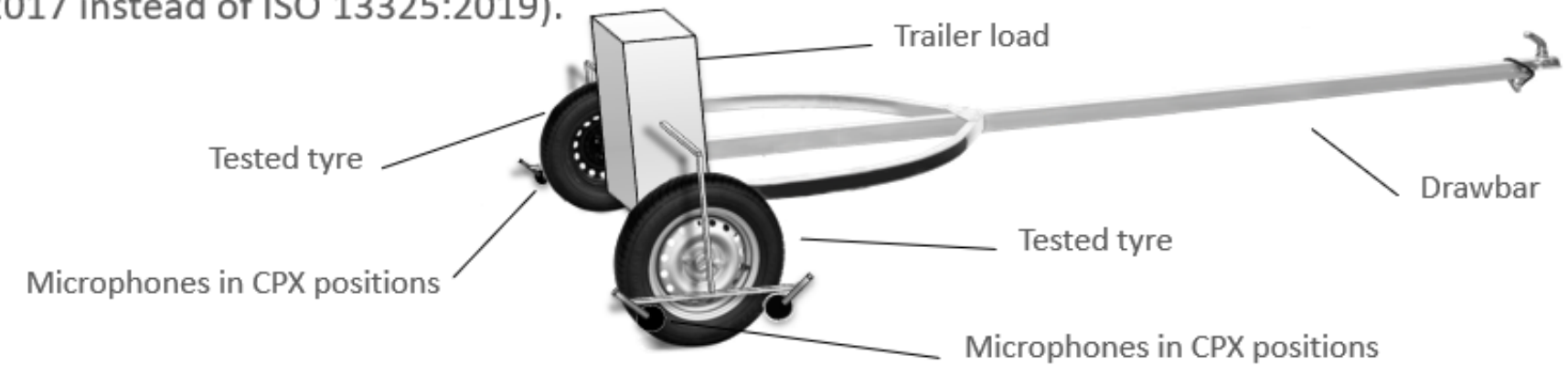
Proposed changes in the Tyre Labelling Procedure regarding noise for the short horizon:

1. The proposed within the ELANORE project "**calibration procedure** based on SRTT16, **to reduce track variability**" **should be introduced**
2. The following **reference air temperatures should be used**:
   - **+20 °C** – for summer tyres
   - **+10 °C** – for all-season tyres
   - **+0 °C** – for winter tyres
3. The tyres should be labelled using a test vehicle for which the **tyres are originally fitted as OEM tyres** despite of tyre manufacturer
4. When the test vehicle is not an EV, then during pass-bys the **engine should idling** (gearbox set in neutral position)
5. The tyre (and vehicle) load conditions should be related to the net weight for a test vehicle (including the driver weighting 75 kg) + 75 kg (passenger) + 35 kg of luggage in trunk
6. The tyre inflation pressure should be according the used test vehicle specification for 2 persons on board and small luggage in the trunk
7. **Each specific tyre should be tested** (not just a selected one from the entire family)

Improved Tyre Labelling Procedure for noise

Proposed changes in the Tyre Labelling Procedure regarding noise **for the long horizon**:

1. Measurements should be performed on a **3D printed replica of standardized SMA11 pavement** at least in the wheel tracks (specified in Reg.117)
2. The following **reference air temperatures should be used**:
   - **+20 °C** – for summer tyres
   - **+10 °C** – for all-season tyres
   - **+0 °C** – for winter tyres
3. **The tyres should be labelled using a special (and very simple!) test trailer**, with easy adjustable tyre loading, with the microphones in the close proximity to the test tyres (Reg.117 tyre labelling procedure should be based on ISO 11819:2017 instead of ISO 13325:2019).



Improved Tyre Labelling Procedure for noise

Proposed changes in the Tyre Labelling Procedure regarding noise **for the long horizon**:

4. Measured **noise levels in CPX positions should be recalculated to CPB positions** using a "transfer-function" which should be established for the test pavement (literature data are also available).
5. Tests should be performed at **2 test speeds of 50 and 80 km/h**,
6. The measured **noise values at both speeds should be averaged** to obtain one value, based on which the tyre should be assigned to an appropriate **noise class** within a range **from A to E** (*similar in appearance to the classes of rolling resistance and wet grip*)
7. Tyre load and inflation pressure test conditions should be reconsidered to be consistent with typical operating conditions of the tested tyre (e.g. corresponding to a vehicle load of 2 persons and a small luggage in the trunk)
8. **Each specific tyre should be tested** (not just a selected one from the entire family)

Acknowledgements

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Reports can be downloaded from: https://elanore.mech.pg.gda.pl/en/documents/open-documents

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