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

Technical report on test conditions for CPB and CPX measurements

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CONTENTS

1 INTRODUCTION

This technical report presents results from the analysis of measurements performed on ISO test tracks and on trafficked roads in 2022, with focus on the test conditions and impact for measurement uncertainties. Measurements were performed both according to the controlled pass-by (CPB) and the CPX method. The main results from these measurements, as well as similar measurements made on 3 ISO tracks in 2021, are presented in the deliverable D2.2.

This report contains a detailed analysis of the influence on the microphone positions and the measurement equipment used, both for CPB and for CPX measurements.

In addition to the evaluation of these items, a more detailed analysis of the available temperature procedures has been made, than presented in deliverable D2.2.

2 MICROPHONE POSITIONS

2.1 MEASUREMENT SETUP ON ISO TEST TRACKS

All measurements on the ISO tracks have been made with 2 microphones, on both sides of the vehicle, as according to the specifications given in UNECE Regulation 117 [1], see figure 1. The road surface is specified in ISO 10844 [2].

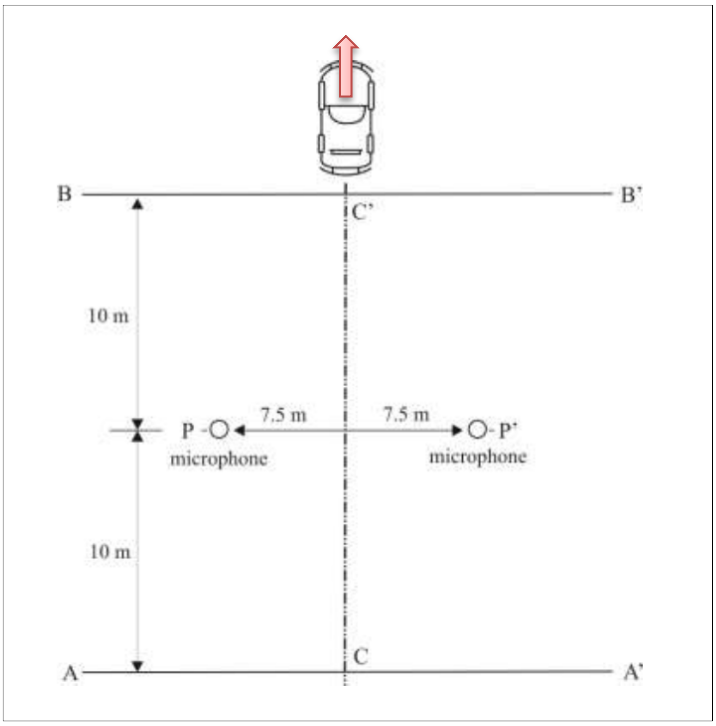

Fig. 1 *Microphone positions according to UNECE Reg.117 [1]*

The vehicle used for testing (Skoda Superb [3]) was only driving in one direction, due to the use of a radar and light barriers for triggering measurements. This means that all measurements of Channel A (GUT instrumentation unit) were for noise levels on the right side of the car, while the levels of Channel B were for the left side of the car. Any differences between the two levels could then either be related to noise differences between the tyres themselves, or differences between the noise behavior of the left or right wheel track. Repeated driving and measurements in each direction could reduce the influence of the wheel tracks, but this was not feasible due to the positions of the radar and trigger system.

2.2 MEASUREMENT SETUP ON TRAFFICKED ROADS

The microphone setup in case of 2 Polish roads (SMA11 and EACC wearing courses) was corresponding to the setup used on ISO test tracks – the microphones were positioned at both sides of the passing vehicle. Due to safety restrictions, measurements on the other trafficked roads were performed with 2 microphones positioned only on the right side of the vehicle in the case of the 2 Norwegian road surfaces (MA11 and SMA16) and on the left side of the vehicle on 1 Polish road surface (SMA8). On these locations, it was not feasible to set up high masts (> 5 m high) to lead the cable from the left side of the vehicle to the right side, where all the measurement equipment was installed.

The two microphones were set approximately 20 m apart, as shown in figure 2. Channel A was connected to the 1st microphone in line and Channel B the 2nd microphone (following the vehicle passing direction).

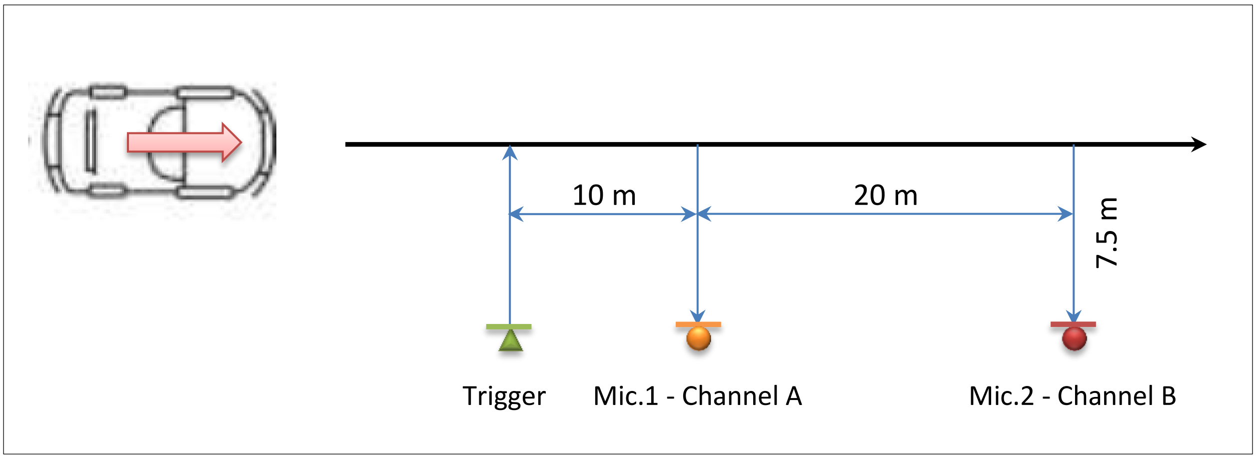

Fig.2 *Microphone setup on trafficked roads*

When approaching the light barrier (*Trigger*), the gear selection was set in neutral position (N) (cruise-by position) and thus the speed at Mic.1 could be somewhat higher than at Mic.2. Since the actual speed at each microphone position was available from the speed measuring device from GUT, the measurements at each position can be treated as two individual measurements.

3 MEASUREMENT EQUIPMENT

3.1 CPB MEASUREMENTS

Originally, it was planned to use 2 independent measurement systems for all the measurements on the four ISO tracks and on the two Norwegian road surfaces:

1. Measurement system – property of GUT
2. Measurement system – property of SINTEF

Due to some unexpected problems (mostly related to calibration of the system) with the SINTEF system, it was only possible to compare the results for the measurements on ISO4 (Reg.117 test conditions). The results are presented in chapter 5.1.1.

The GUT's system setup is shown in figure 3.

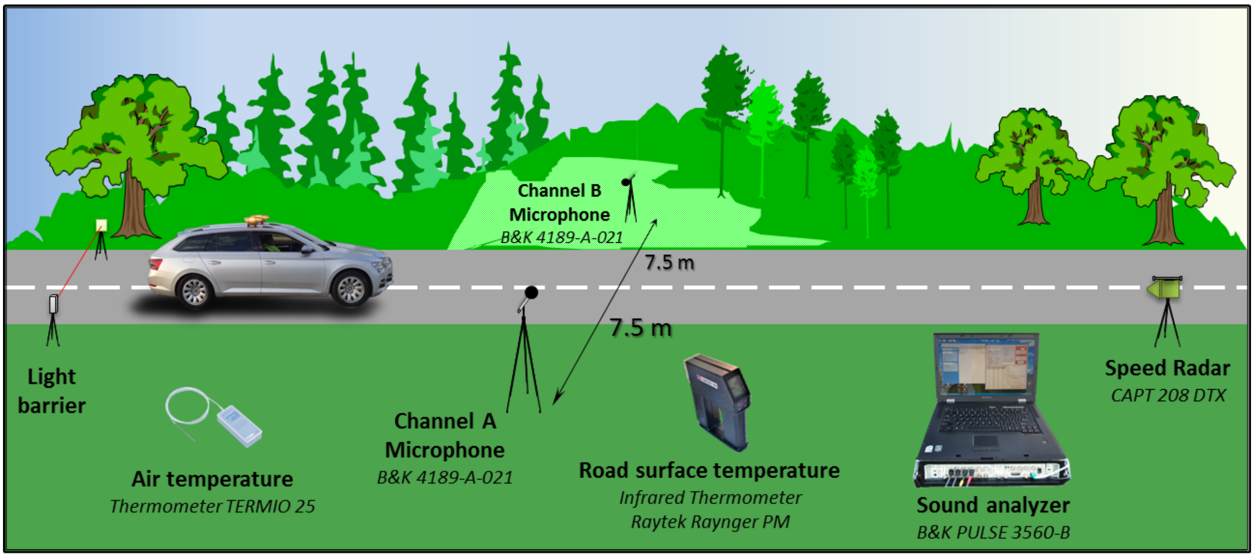

Fig. 3 *Layout of GUT's measurement system*

It is based on B&K PULSE multichannel real-time sound analyzer controlled by laptop computer. In the front of the test lane there is a radar unit continuously measuring vehicle speed. The sound pressure levels of two channels (right and left microphone) and third-octave band frequency spectra, together with the actual speed of the test vehicle and its position, are recorded for each 1.0 m section of the measurement distance starting 20 m in front of the microphone's line (the light barrier line triggering measurement) and ending automatically 40 m behind that line (60 m in total of measuring distance). The ambient air and road surface temperatures are acquired manually by an operator during each vehicle pass-by measurement. A dedicated software, written by the co-author of this report, was used to control measurements and store all data.

The SINTEF system is PC based, with a measurement setup specially developed for this project, based on a Labview layout. For vehicle speed measurements, the system used light barriers before and after the measurement area (40 m distance between both barriers). By measuring the distance between the light barriers, the average speed over the test section could be calculated based on the time signal between the barriers. For each pass-by, a wav file was recorded. The measured noise level from each channel was available on the screen of the laptop, as well as the recorded vehicle speed. The wav files were available for pre-processing of results. A combined air and road surface temperature device was used, and the intention was that the temperatures during the pass-by should be recorded at the laptop together with the noise levels. However, during testing of this device, it failed to give reliable results, so this automatic system had to be skipped and manual reading of temperatures during measurement series had to be applied. Figure 4 shows the setup of the SINTEF's system.

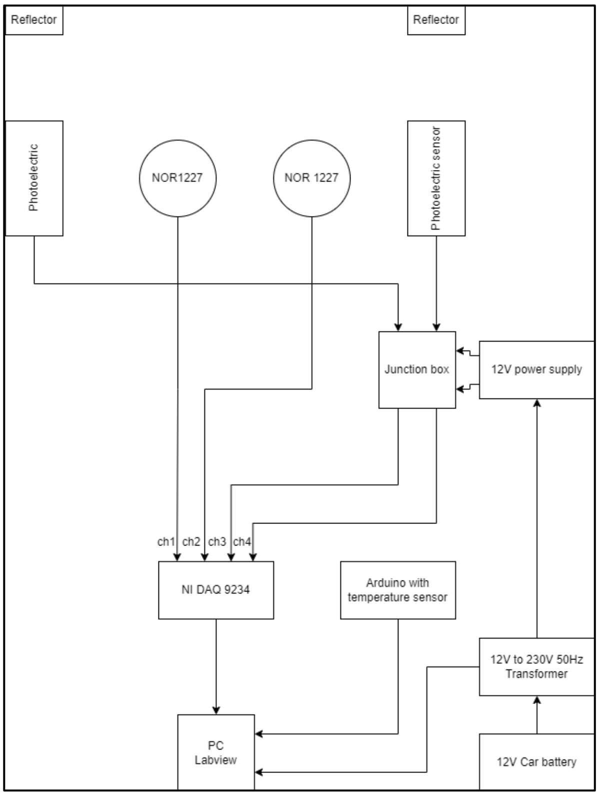

Fig.4 *Lay-out of SINTEF's measurement system*

The motivation for this dual setup was to investigate the overall measurement uncertainties by using two different measurement systems at the same time. Figure 5 shows a picture from measurement site at one of the locations.

Fig.5 *Parallel GUT and SINTEF measurements*

To minimize any noise differences between the two systems, the microphones were mounted as close to each other as possible, as shown in figure 6.

Fig.6 *Parallel microphone setup*

3.2 CPX MEASUREMENTS

On the two Norwegian road surfaces, both the GUT CPX trailer and the trailer owned by the Norwegian Public Roads Administration were used (figure 7).

The GUT trailer is equipped with single test tyre, while the Norwegian trailer has two test tyres (see figure 8). Thus, for comparison of measured noise levels, the GUT trailer should drive 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.

Fig.7 *CPX trailers: Norwegian (left) and Polish (right)*

Fig.8 *The interior of CPX trailers: Norwegian (left) and Polish (right)*

Normally, the speed of the towing vehicle for the Norwegian trailer has been measured with a dynamic GPS device from Racelogic (V-Box). The signal from this device is directly connected to the front-end for microphone signals (PAK system) and recorded at the same time as the noise levels. However, 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. This introduces 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.

4 TEMPERATURE CORRECTION PROCEDURES

It is well documented that the pass-by tyre/road noise levels are dependent on temperature [5].

The change of noise level can be related to:

- the tyre temperature
- the ambient air temperature
- the road surface temperature

The selection of which temperature to be used for compensation comes with different advantages and disadvantages.

For all three types of temperature, it must be further specified where these temperatures shall be measured. Tyre temperatures vary dramatically depending on where in or on the tyre they are measured and are even subject to variations in time, depending on tyre operation. Road or test track surface temperatures may be quite different depending on how far from the surface they are measured, and air temperatures are likewise dependent on how far above the road surface they are measured.

It is recognized that the tyre temperature is the most relevant, however it is also the most difficult to measure.

The tyre/road noise is highly influenced by the stiffness change of a tyre over a temperature range, as shown in Figure 9. For different rubber compounds, the temperature sensitivity can vary considerably according to their noise performance. One of the main influencing factors is the rubber glass transition temperature.

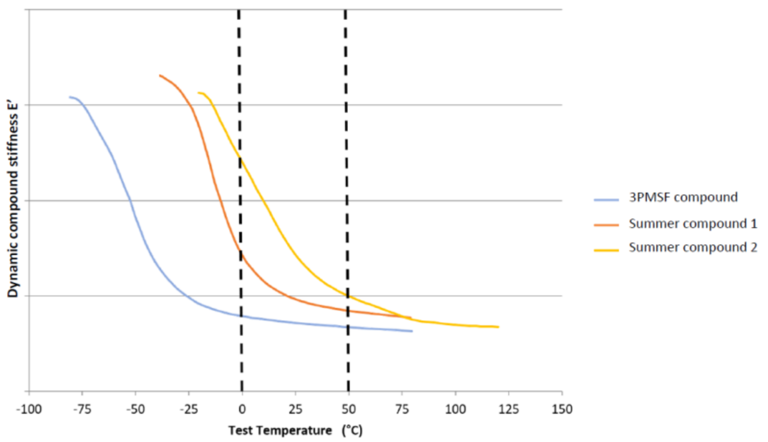

Fig.9 *Example of dynamic stiffness and test temperature for 3 different tyre rubber compounds [6]*

The figure shows a clear non-linear behavior to the dynamic stiffness, and thus it is likely to expect a similar non-linear behavior between the pass-by noise level and the tyre temperature.

Due to the complexity of using the tyre temperature, the air or the road surface temperature has been chosen to be used in standardization and/or regulative work. The different compensation methods are described in the following chapters.

4.1 TEMPERATURE CORRECTIONS IN UNECE REG.117

The UNECE Regulation 117 [1] specifies the approval of tyres regarding the characteristics of rolling sound emissions, adhesion on wet surfaces, and rolling resistance. The regulation first entered into force in January 2011. Since then, four amendments of this regulation have been made, but the temperature correction procedure has been unchanged.

Regarding the temperature correction proposed by Reg.117, a procedure for normalizing the results to a reference temperature of 20 °C is provided for tyres belonging to classes C1 and C2 only. The temperature correction is carried out by applying the following equation:

$$L_R((\vartheta_{ref}) = L_R(\vartheta) + K(\vartheta_{ref} - \vartheta) \quad (1)$$

where ϑ is the measured test surface temperature, and ϑ_{ref} is the reference temperature of 20 °C. The coefficient K is defined according to the tyre class and the difference between measured surface temperature and the reference temperature, as shown in *Tab. 1*. The speed ranges and reference speeds for each tyre class are also shown in the same table. The procedure is illustrated in Figure 10.

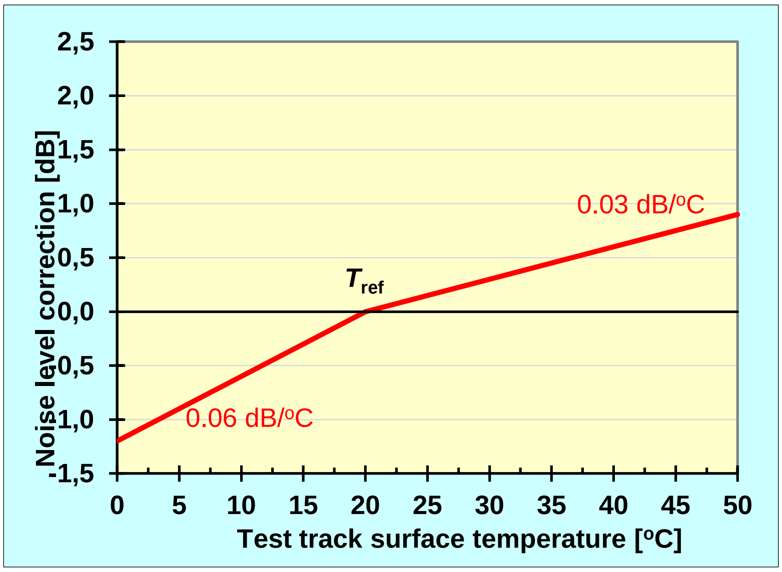

Fig.10 *The noise-temperature relation that is used for car (C1) tyres in ECE Reg.11 (figure from STEER [5])*

Tab. 1 *Temperature correction coefficient according to ECE R117 and some test requirements. Note that the Regulation still uses the unit dB(A), which is not allowed according to ISO terminology standards. The unit shall be dB and not dB(A).*

Tyre class	Speed range	Reference speed	Road temperature ϑ	Correction coefficient, K
C1	70-90 km/h	80 km/h	$> \vartheta_{ref}$	-0.03 dB(A)/°C
			$< \vartheta_{ref}$	-0.06 dB(A)/°C
C2				-0.02 dB(A)/°C
C3	60-80 km/h	70 km/h	-	-

The origin of this correction procedure date back to the introduction of the tyre/noise regulation in 2001 (EU directive 2001/43/EC), primarily based on input from the tyre industry and was based on a limited number of tyres measured over the allowed temperature range and with poor correlation ($R^2 < 0.5$) [6]. Access this database has also not been possible.

The procedure has since been adopted to several other EU regulations, like EC 661/2009 [7] (replacing 2001/43/EC) and EC 1222/2009 [8] (Labelling of tyres).

4.2 NEW PROPOSAL FOR TEMPERATURE CORRECTION IN REG.117

As shown above, the data for the present correction procedure is based on old and limited data. Due to the discussions on which temperature to use (air or road surface), the tyre industry (ETRTO) has presented a recent study on the subject [6].

The relationship between air and track surface temperature was investigated for 5 different ISO tracks as shown in figure 11.

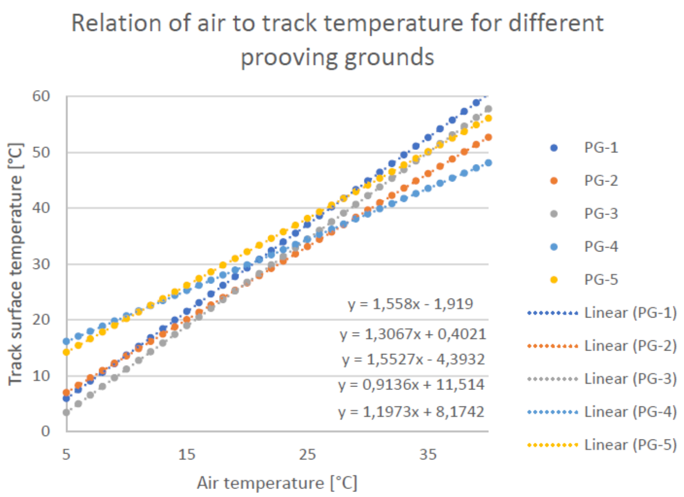

Fig.11 *Slope of relationship between air and track temperature for 5 ISO tracks (Proving Grounds) [6]*

Based on these slopes, the conversion from a track reference temperature of 20 °C would give an air reference temperature which varies from + 9.3 °C to +15.7 °C, depending on the ISO track. According to their conclusions, a change from test track temperature to air temperature will introduce an uncertainty, which should be avoided.

In the same study, ETRTO performed measurements on an ISO track with three sets of C1 summer tyres and a winter tyre of type 3PMSF (3 Peak Mountain Snow Flake). The results were presented to the Informal Working Group on Measurement Uncertainties (IWG MU) at a meeting in Paris in November 2022 [6]. In addition to measurements on the ISO track, the tyres were also measured on a drum facility with a replica of an ISO surface on the drum. Figure 12 shows the measurements on the ISO track of these 4 tyres. Tyre summer 1 PG (blue dots) is a typical tyre for sportive cars, tyre summer 2 PG (grey dots) is a tyre for normal use, and tyre summer 3 PG (yellow dots) is a tyre optimized for rolling resistance.

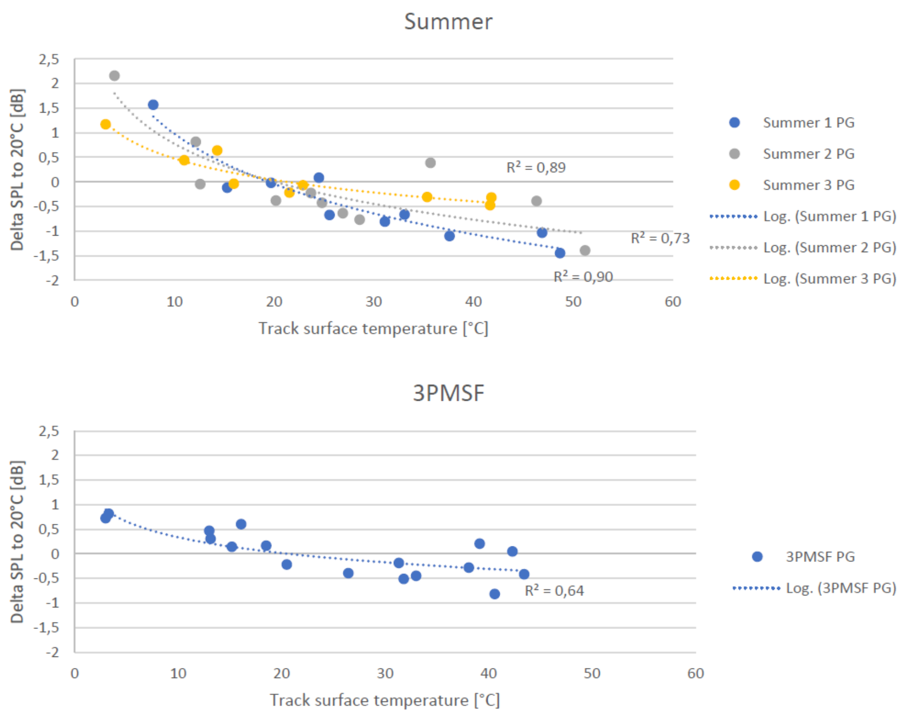

Fig.12 *Correction factors based on track surface temperature for four different tyres [6]*

As shown in the figure, the data points for temperatures below + 10 °C are very limited for all sets of tyres. However, all summer tyres show a regression coefficient > 0.70, which was the aim of the regression analysis. This indicates a non-linear relationship between the test track temperature and the noise levels.

More investigations from different ISO tracks and with more tyres should be made, to support these data.

However, based on this investigation, IWG MU has now proposed the following changes of the temperature correction in Reg.117 for class C1 tyres [9]:

$$L_i(\vartheta_{\text{ref}}) = L_i(\vartheta_i) - K_1 \cdot \lg\left(\frac{\vartheta_{\text{ref}}+K_2}{\vartheta_i+K_2}\right) \quad (2)$$

Where ϑ_{ref} = 20 °C and the coefficients K_1 and K_2 are given in the table below:

Tab.2 *Correction coefficients in equation 2.*

Category of use		***K_1* *[°C]***	***K_2* *[°C]***
Normal tyre		2.18	0
Snow tyre		2.18	0
	Snow tyre for use in severe snow conditions	1.35	2.29
Special use tyre		2.18	0
	Special use tyre for use in severe snow conditions	1.35	2.29

Figure 13 shows the proposed correction factors for the two different categories of C1 tyres, compared to the present procedure in Reg.117.

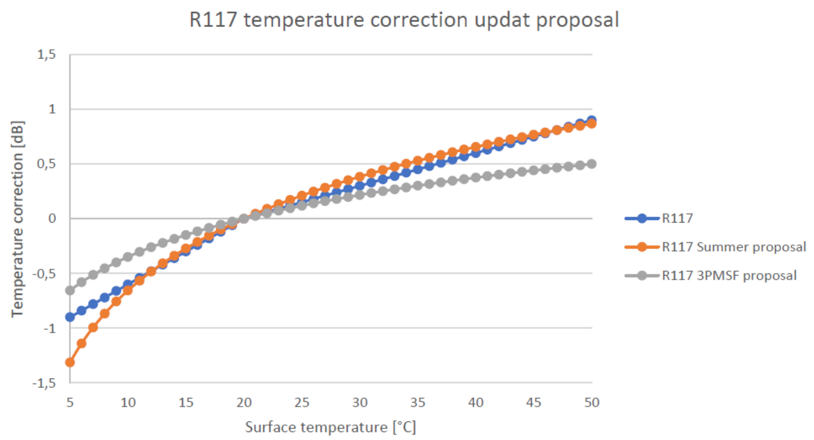

Fig.13 *New and old correction based on track surface temperatures [9].*

This proposal was submitted as an Informal Document [9] to the 77^{th} session of GRBP in Geneva, 7-10 February 2023. A Working Document for amendments of Reg.117 is expected for the 78th session of GRBP in Aug/Sept. 2023.

As for now, this is only valid for C1 tyres. ETRTO is planning to also investigate if there is a need to update the procedure for C2 tyres, or if the current procedure in Reg.117 is representative for this class of tyres. An Informal Document on C2 tyres is expected for the 78th session of GRBP.

4.3 TEMPERATURE CORRECTION IN ECE REG.51.03

ECE Reg.51.03 [10] defines the noise type approval testing procedure and noise limits for vehicles of classes M and N. For vehicles of category M_1 and N_1, the test procedure consists of two different tests; an acceleration test at defined entrance speeds and gear selection, and a constant speed test at a reference speed of normally equal to 50 km/h. The constant speed test is to determine the tyre/road noise contribution to the overall noise level.

In the latest proposal for amendment of this regulation [11], a temperature correction procedure has been defined. This correction procedure is based on **air** temperature and the correction is as follows:

For each individual test run (gear, condition and vehicle side), a tyre rolling sound reference shall be calculated for the applicable air temperature $\vartheta_{crs,j}$.

$$L_{TR,crs,j,\vartheta crs} = L_{TR,crs,j,\vartheta_{ref}} + K_1 \times \lg\left(\frac{\vartheta_{ref}+K_2}{\vartheta_{crs,j}+K_2}\right) \quad (3)$$

where ϑ_{ref} = 20 °C and

K_1 = 3.4 for C_1 and C_2 tyres and

K_2 = 3.0 for C_1 tyres and

K_2 = 15.0 for C_2 tyres

Even if the correction procedure here is based on **air** temperature, it follows the non-linear correction procedure as now proposed for C1 tyres for Reg.117.

4.4 TEMPERATURE CORRECTION PROCEDURE IN ISO/DTS 13471-2

Within ISO, WG27 has developed a standard for temperature correction procedures for pass-by noise measurements, ISO/DTS 13471-2:2021 [12].

The temperature correction procedure in this standard is a semi-generic one that, similar to ISO/TS 13471-1:2017 [13] adopts the reference temperature of 20 °C. The correction was empirically determined based on the relationship between tyre/road noise and ambient air temperature from a compilation of several published investigations [5].

According to the standard, it is mandatory to measure air temperature and optional to measure road and tyre temperature. The air temperature measurement shall have a duration of at least 15 s and the resulting reading shall be rounded to the first decimal, in °C. The applicable air temperature range for the correction procedure is 5 – 35 °C. The temperature correction term is given by equation 4.

$$C_{T,t} = -\gamma_t(T - T_{ref}) \quad (4)$$

where $C_{T,t}$ is the noise level L_{Amax} correction for a measurement temperature (*T*) and a tyre or vehicle class (*t*), γ_t is the temperature coefficient for tyre or vehicle class *t,* in dB/°C (either C1, C2 or C3 for tyre class, or either P1 or H for vehicle class in SPB measurement), *T* is the air temperature during measurement, in °C, and T_{ref} is the reference temperature of 20 °C. The temperature coefficient for each tyre class is shown in Table 3.

Tab.3 *Temperature coefficient for each tyre class and road surface category in the draft for ISO/TS 13471-2. Note that corrections will have the opposite sign.*

Surface type	**C1**	**C2**	**C3**
Dense asphaltic surfaces	-0.10	-0.10	-0.06
Cement concrete surfaces	-0.07	-0.07	-0.06
Porous asphalt surfaces	-0.05	-0.05	-0.04

As equation 4 and table 3 show, the correction here is linear and especially for air and road temperatures in the higher ranges (> 30 °C), the correction using this ISO standard will give a ***higher*** noise level than using Reg.117. These differences in correction procedures and consequences for the noise labelled values are discussed and presented in chapter 5.3.

5 COMPARISON OF MEASUREMENT SYSTEMS

5.1 MEASUREMENT UNITS

5.1.1 COAST-BY MEASUREMENTS

Only measurements on ISO4 with the test conditions according to Reg.117 were available for direct comparison of the obtained results with the GUT and the SINTEF measurement equipment. The noise levels are the average of left and right side of the vehicle.

Figure 14 shows the linear regression analysis performed for all 5 tyres.

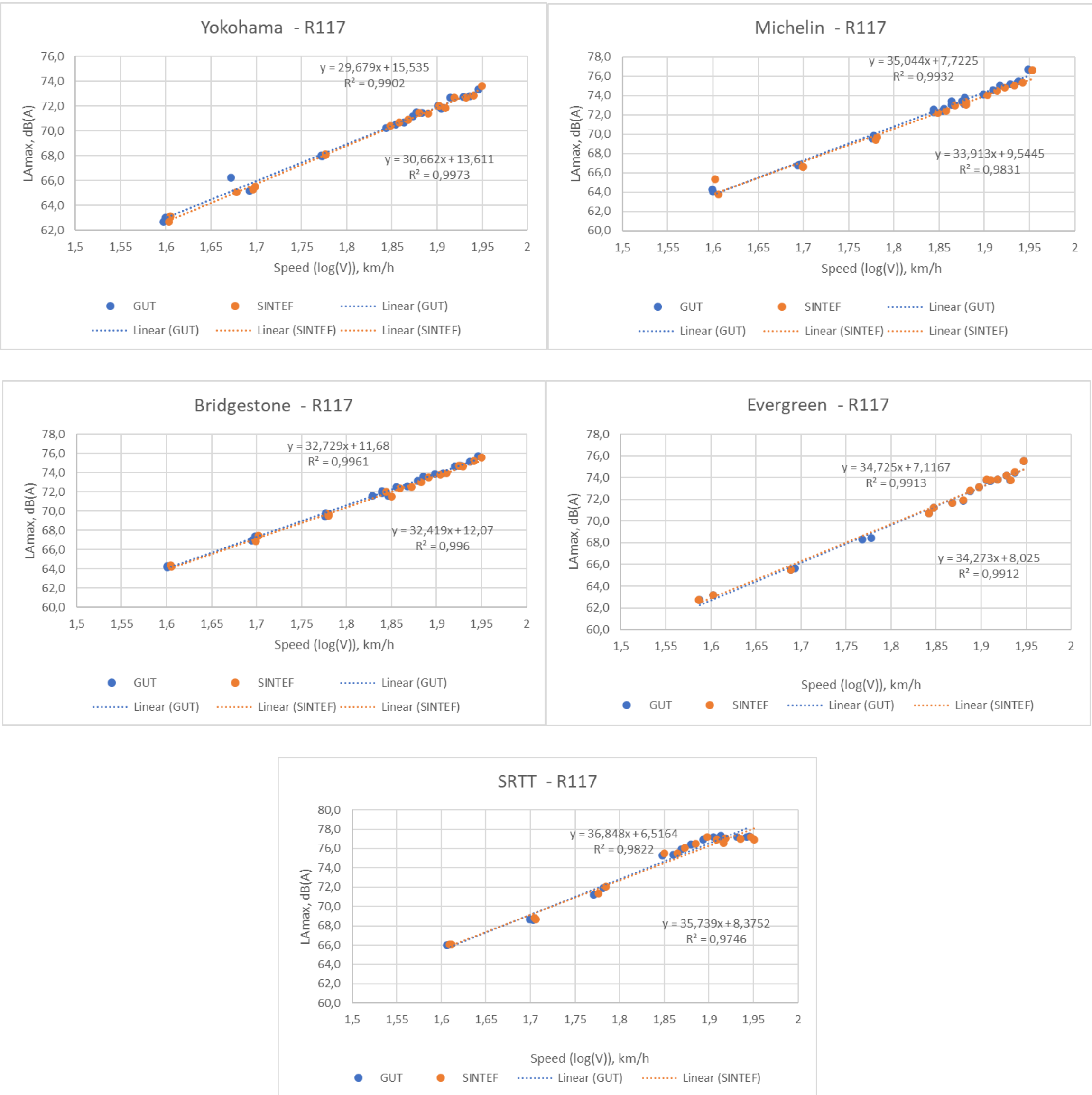

Fig.14 *Linear regression analysis for comparison of GUT and SINTEF measurement systems*

In table 4, the measurement results for Reg.117 are shown from the regression analysis, together with the differences.

Tab.4 *Measured differences in noise levels from the GUT and SINTEF measurement systems.*

Tyre	GUT [dB]	SINTEF [dB]	Difference [dB]
Yokohama	72.02	71.97	0.05
Michelin	74.41	74.08	0.33
Bridgestone	73.97	73.77	0.20
Evergreen	73.20	73.25	-0.05
SRTT	76.64	76.39	0.25

In general, there is a small and acceptable difference between the two systems. During the development of the uncertainty analysis, both for ECE Reg.51.03 (based on the uncertainty analysis of ISO 362-1 [14]) and for Reg.117, it is shown that a variation of ± 0.4 dB could be expected between two different sound level meters (not taking into account the influence of the calibrator variability) [15, 16]. The above table shows that our results are within this documented uncertainty.

5.1.2 CPX MEASUREMENTS

Figure 15 shows the comparison of measurement results using both CPX trailers on the MA11 road surface, for 50 and 80 km/h. Figure 16 shows the same comparison on SMA16 surface.

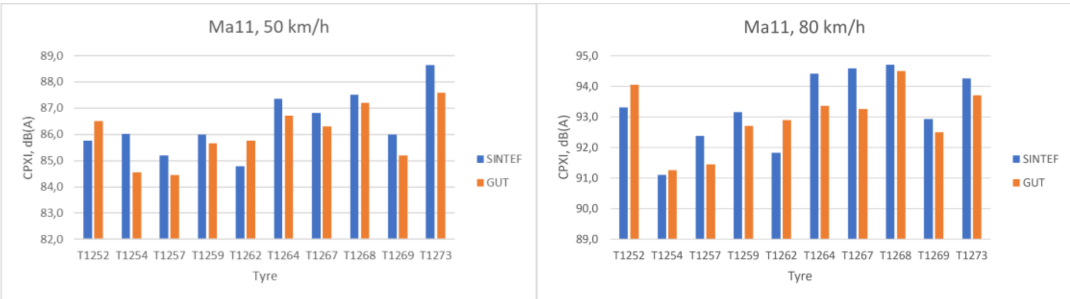

Fig.15 *Comparison between the GUT and the Norwegian CPX trailer on the MA11 surface.*

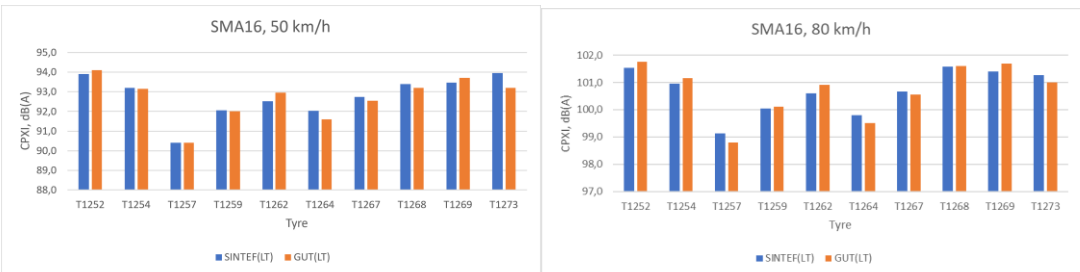

Fig.16 *Comparison between the GUT and the Norwegian CPX trailer on the SMA16 surface.*

Note that all measurements were made with the "light test", i.e. tyre load and tyre inflation pressure according to the CPX standard (ISO 11819-2 [17]).

On the MA11 surface, there are higher differences than on the SMA16 surface. For some of the tyres, the Norwegian trailer measures 1.0 - 1.3 dB higher than the GUT trailer on the MA11 surface. The difference is higher at 80 km/h than at 50 km/h. The 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, the 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. On the SMA16 surface, the differences are smaller (< 1 dB), indicating a homogenous road surface. Taken into account that a default speed of 50 and 80 km/h was used for the analysis of the SINTEF results, the agreement is acceptable.

Since only the "light test" was possible on the Norwegian trailer, SINTEF had the possibility to repeat all measurements on the SMA16 surface the following day, when GUT performed new measurements with different load and tyre inflation pressure (according to Reg.117). This extra measurement could then show the reproducibility of the Norwegian trailer, especially with focus on using the GPS speed device on the mobile phone and not being able to record the speed simultaneously with noise levels. Figure 17 shows the results for 50 and 80 km/h.

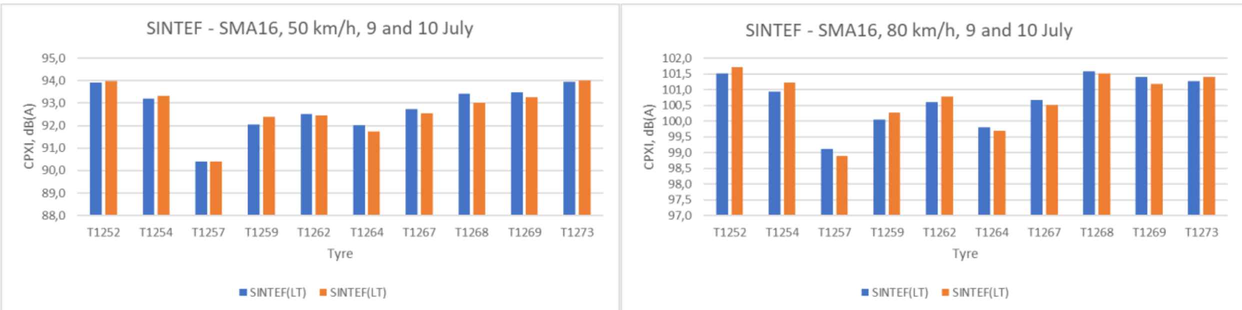

Fig.17 *Repetition of measurement using the Norwegian CPX trailer on the SMA16 surface at two different days.*

In general, the difference is small, around 0.1 - 0.2 dB, which is below the expected uncertainty of the method (expanded uncertainty with 95 % confidence of 1 dB [15]). The highest difference is 0.4 dB (tyre T1268) at 50 km/h.

5.2 MEASUREMENT POSITIONS

5.2.1 DIFFERENCES BETWEEN SIDE OF VEHICLE

As stated in chapter 2.1, the final pass-by level is based on the average of the left and right side of the vehicle. Since the tests done on the ISO tracks were only conducted in one direction, any differences in noise levels on the sides of the vehicle can be related both to any differences in the road surface itself, or differences due to the noise performance of tyres. However, it is assumed that the noise differences in tyres mounted on the left and right side are the dominate source.

Table 5 shows the measured results from both sides of the vehicle for the R177 test. Channel A is always on the right side of the vehicle.

Tab.5 *Noise differences between right side (Ch.A) and left side (Ch.B) at 3 ISO tracks. All values are according to R117 (dB(A)).*

Tyre	ISO1			ISO2			ISO4		
	Ch.A	**Ch.B**	**Diff.**	**Ch.A**	**Ch.B**	**Diff.**	**Ch.A**	**Ch.B**	**Diff.**
Yokohama	70.9	71.3	-0.4	71.6	72.1	-0.5	71.7	71.5	0.2
Michelin	72.3	72.8	-0.5	75.9	77.8	-1.9	73.8	74.3	-0.5
Bridgestone	71.8	71.8	0.0	72.5	73.5	-1.0	73.7	73.5	0.2
Evergreen	71.7	71.3	0.4	72.3	73.2	-0.9	72.8	72.4	0.4
SRTT	73.7	75.5	-1.8	75.0	77.7	-2.7	75.2	77.4	-2.1

The results show that in general there is a rather small difference between the right and left side for the tyres on ISO1 and ISO4 test tracks, except for the SRTT tyres. There seems to be a consistent lower level of the two tyres mounted on the right side (Channel A) of the vehicle as shown in figure 18. On ISO2, there may be a difference also related to the wheel tracks, as there are lower levels on the left wheel track for most of the tyres. However, measurements of MPD values of the right and left wheel track at ISO2 test track did not reveal any differences in these values.

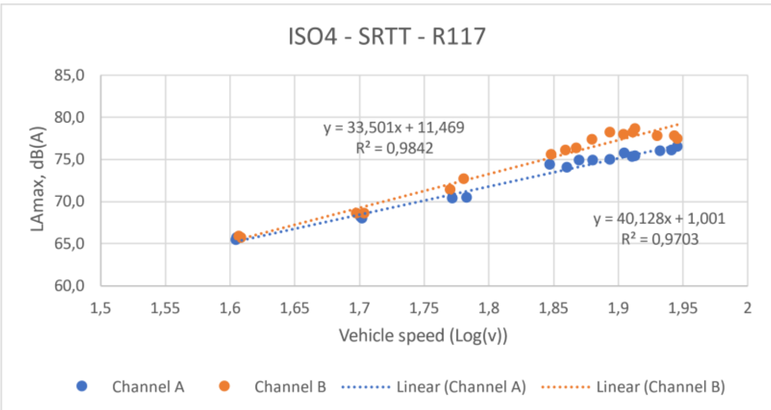

Fig.18 *Linear regression analysis of Ch.A and Ch.B for the SRTT tyre on ISO4 test track*

5.2.2 DIFFERENCES BETWEEN FIRST AND SECOND MICROPHONE ON ROADS

As described in chapter 2.2, the two microphones (Channel A and Channel B) were placed on the same side of the road, 20 m apart.

Table 6 and Table 7 show the differences between the two channels from all performed measurements (both conditions: Reg.117 and LT) on MA11 and SMA16. Since the measurement is a coast-by (engine still on, but gear selector in Neutral position), the speed of the vehicle may be somewhat reduced when passing the second microphone (Channel B in figure 2). Since the vehicle speed is measured at each of the two microphone positions, the average difference in the speed is also presented together with the difference in noise levels.

Tab.6 *Noise differences between Ch.A and Ch.B on MA11 and SMA16. Reg.117.*

Tyre	Ma11				SMA16			
	ChA [dB]	ChB [dB]	Diff. ChA-ChB [dB]	Av. Speed diff. km/h	ChA [dB]	ChB [dB]	Diff. ChA-ChB [dB]	Av. Speed diff. km/h
Yokohama	74.3	74.6	-0.3	0.57	77.2	77.3	-0.1	0.82
Michelin	75.1	75.0	0.1	0.57	75.9	76.0	-0.1	1.02
Bridgestone	74.8	74.9	-0.1	0.58	76.1	76.0	0.1	1.09
Evergreen	74.6	74.7	-0.1	0.57	77.2	77.3	-0.1	0.96
SRTT	75.3	75.0	0.3	0.56	76.8	76.9	-0.1	1.08

Tab.7 *Noise differences between Ch.A and Ch.B on MA11 and SMA16. Light test.*

Tyre	Ma11				SMA16			
	ChA [dB]	ChB [dB]	Diff. ChA-ChB [dB]	Av. Speed diff. km/h	ChA [dB]	ChB [dB]	Diff. ChA-ChB [dB]	Av. Speed diff. km/h
Yokohama	74.1	74.0	0.1	0.62	77.6	77.8	-0.2	1.16
Michelin	74.7	74.2	0.5	0.64	76.0	76.1	-0.1	1.04
Bridgestone	75.1	74.6	0.6	0.64	76.2	76.4	-0.3	0.88
Evergreen	74.8	74.5	0.3	0.54	77.7	77.8	-0.1	0.93
SRTT	75.5	74.5	1.0	0.63	77.2	77.4	-0.2	1.01

In general, the difference between the two channels is small, in the range 0.1 - 0.3 dB. During the light test on the MA11 pavement, the differences are somewhat higher, up to 1 dB. This difference cannot be explained by speed differences. However, during these measurements, the wind was quite strong, on average around 5 m/s, but up 8 - 10 m/s during gusts of wind. This may have affected the measured noise levels differently in the two microphone positions (depending on wind direction).

5.3 TEMPERATURE CORRECTION PROCEDURES

The noise levels according to Reg.117 are presented as follows:

1. No temperature correction applied
2. Temperature correction according to Reg.117 (road surface temperature)
3. Temperature correction according to ISO (air temperature)
4. Temperature correction according to new proposal from ETRTO (road surface temperature).

All these corrections have been applied to the measurements on the ISO4 track.

Table 8 shows the range of air and road surface temperatures during the measurements.

Tab.8 *Air and road surface temperature during measurements on ISO4 test track.*

Test	Reg.117		Light Test	
Tyre	Air temperature, °C	Road surface temperature, °C	Air temperature, °C	Road surface temperature, °C
Yokohama	20.3	33.5 - 34.3	16.8 - 18.6	32.8 - 35.0
Michelin	15.8 - 18.3	30.8 - 35.2	15.7 - 16.4	29.2
Bridgestone	21.8 - 22.8	35.8 - 37.7	18.4 - 19.9	33.2 - 35.4
Evergreen	22.7 - 24.1	38.0 - 41.6	18.0 - 19.4	34.4
SRTT	19.9 - 20.0	31.0 - 31.8	19.0 - 20.1	35.4 - 35.9

In table 9 and figures 19-20, the measured results on ISO4 are shown for Reg.117 and Light Test, applying the 4 different procedures listed above.

Tab.9 *Measured and corrected noise levels applying different temperature correction procedures on ISO4 test track. All values in dB(A).*

Tyre	Reg.117				Light Test			
	No corr.	Reg.117	ISO	ETRTO	No corr.	Reg.117	ISO	ETRTO
Yokohama	71.6	72.0	71.6	72.1	71.4	71.8	71.2	71.9
Michelin	74.0	74.4	73.8	74.3	73.7	74.0	73.4	73.9
Bridgestone	73.5	74.0	73.7	73.8	73.9	74.3	73.8	74.1
Evergreen	72.6	73.2	73.0	73.3	72.8	73.2	72.7	73.3
SRTT	76.3	76.6	76.3	76.7	75.9	76.4	75.8	76.4

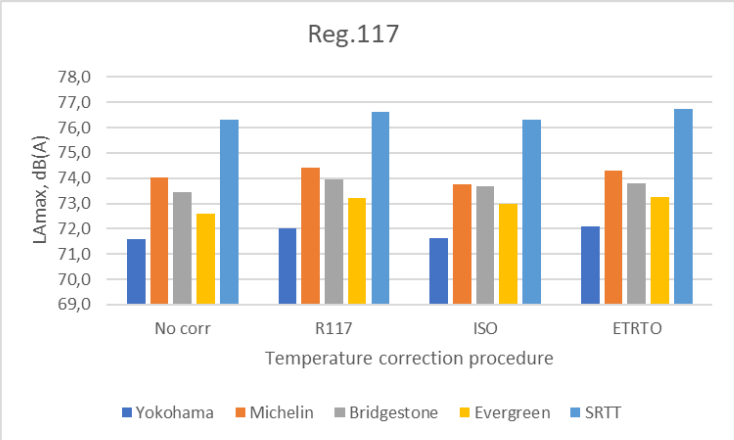

Fig.19 *Measured and temperature corrected levels on ISO4. Reg.117 test.*

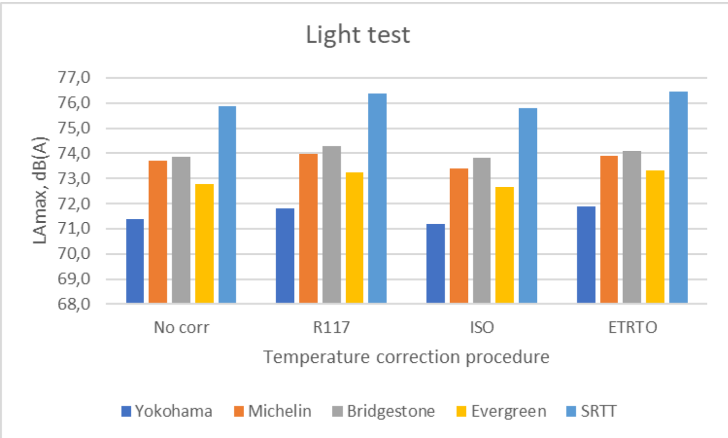

Fig.20 *Measured and temperature corrected levels on ISO4. Light Test.*

According to table 8, the air temperature for all tyres is quite close to the reference temperature of +20 °C. This means that the corrected levels according to the ISO standard for the Reg.117 test are very small, 0.0 - 0.2 dB, except for the Evergreen tyre, where the correction is 0.4 dB.

The road surface temperatures were all in the range of +30 – 40 °C. Using the Reg.117 procedure, this means that the correction is +0.03 dB/°C (see figure 10). All measured levels (non-corrected) will then have an addition of levels in the range of 0.3 - 0.6 dB. This is shown in table 9. As figure 13 shows, there is only a minor difference in the existing Reg.117 correction procedure for temperatures above the reference temperature, and as shown in table 9, there is only a minor difference in corrected levels between the two procedures, as could be expected.

However, the most important result of these correction procedures is that the noise ranking of the tyres do not shift, independent of the procedure used. But it is still important to implement a temperature correction procedure, to reduce uncertainties.

Table 10 shows that the labelled noise values based on the different temperature correction values do not differ. However, as shown in the table, these values do not correspond to the labelled values given by the tyre manufacturer.

Tab.10 *Labelled values in dB(A) based on different temperature correction procedures. All measurements on ISO4 (execpt EU values).*

Tyre	EU label	Reg.117	ISO	ETRTO
Yokohama	67	72	72	72
Michelin	69	74	74	74
Bridgestone	71	74	74	74
Evergreen	74	73	73	73

6 CONCLUSIONS

In this Technical report, the following conclusions can be drawn:

1. The use of two independent measurement systems (sound and vehicle speed) gave a variation of less than 0.3 dB between the two systems, which is less than the standard uncertainty given for variation between sound level meters; ± 0.4 dB [16].
2. The measured noise differences between the two CPX trailers used on the two Norwegian pavements were in the range of 1 - 1.3 dB on the MA11 and < 1 dB on the SMA16 surface. This is an acceptable difference, considering the different types of CPX trailers used.
3. Repeated measurements with the Norwegian CPX trailer in two consecutive days showed a difference of < 0.3 dB, despite lack of a continuously recorded speed measuring device.
4. Comparing noise levels on both sides of the test vehicle showed a difference of less than 0.5 dB on ISO1 and ISO4 test tracks for the 4 conventional tyres. On ISO2, this difference was somewhat higher, up to 2 dB. The difference between the SRTT tyres mounted on the left side gave consistently higher levels on the right side, in the range of 1.8 - 2.7 dB.
5. The measurement using two microphones 10 m apart, at the same side at the two Norwegian pavements gave small differences, less than 0.6 dB (highest levels of the first microphone in the driving direction). One exception was a difference of 1 dB for the SRTT tyre on the MA11 pavement.
6. Using different temperature correction procedures on the ISO4 measurements did not change the noise ranking of the tyres and not the labelled values based on measurements on this ISO track. It is, however, recommended to use a temperature correction procedure, as this reduces the measurement uncertainties.

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