IWG on MU

10th session , 22nd April 2021

IWGMU-10-03

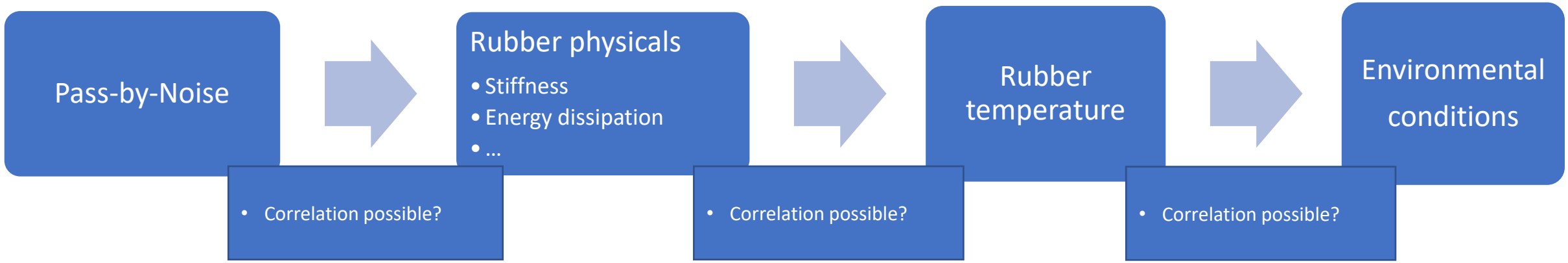
Agenda

Agenda

Non-linearity of temperature corrections

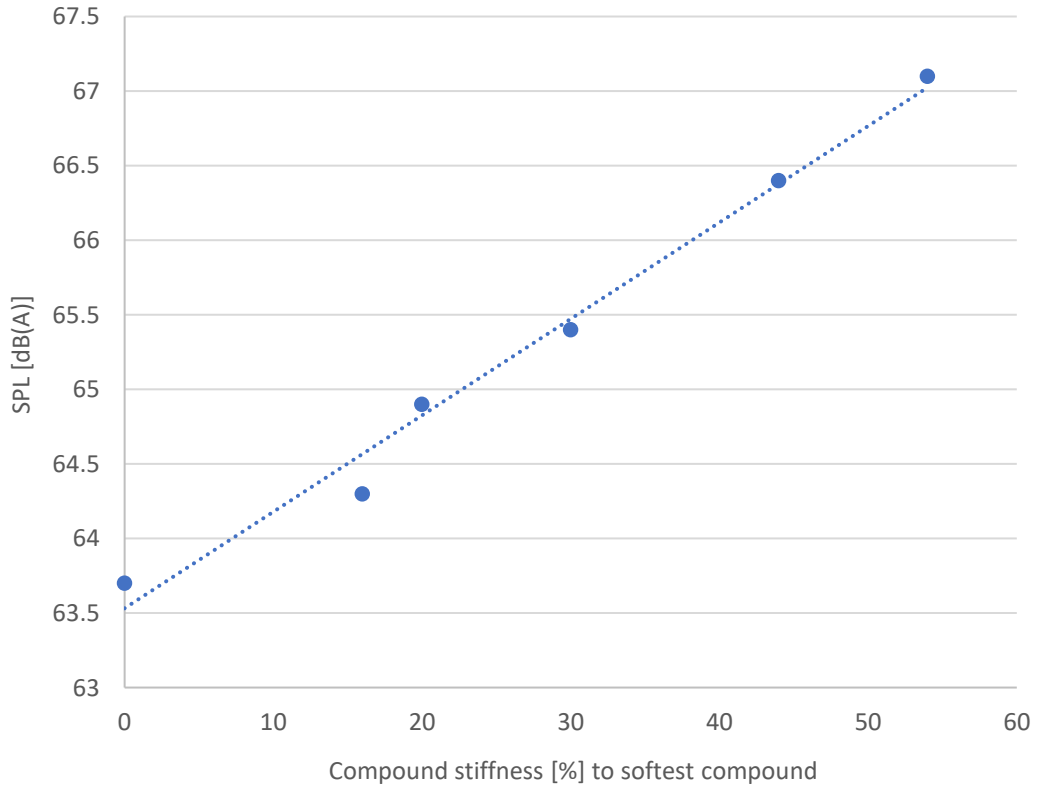
- In their temperature correction model WG27 assumes a linear correlation between tyre rolling noise and air temperature
- Based on pass by noise results and rubber compound properties ETRTO analysed this assumption

Non-linearity of temperature corrections



Pass by Noise - tread compound variation

- Six sets of tyres were built varying only the tread pattern compound and with it the dynamic stiffness
- PbN tests were performed under constant environmental conditions and conformed by indoor drum tests
- **Results show a linear correlation between PbN and compound stiffness**



Non-linearity of temperature corrections

Pass-by-Noise

- Linear correlation

Rubber physicals

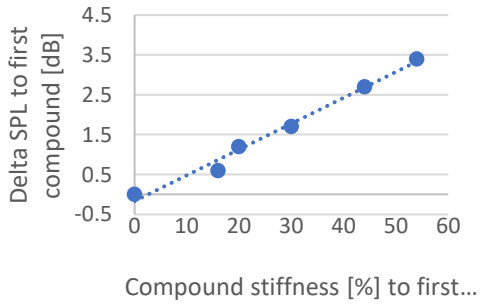
- Stiffness
- Energy dissipation
- …

- Correlation possible?

Rubber temperature

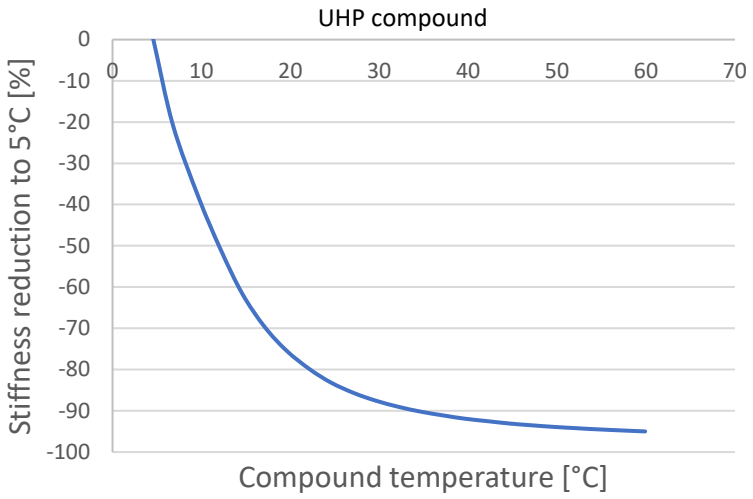
- Correlation possible?

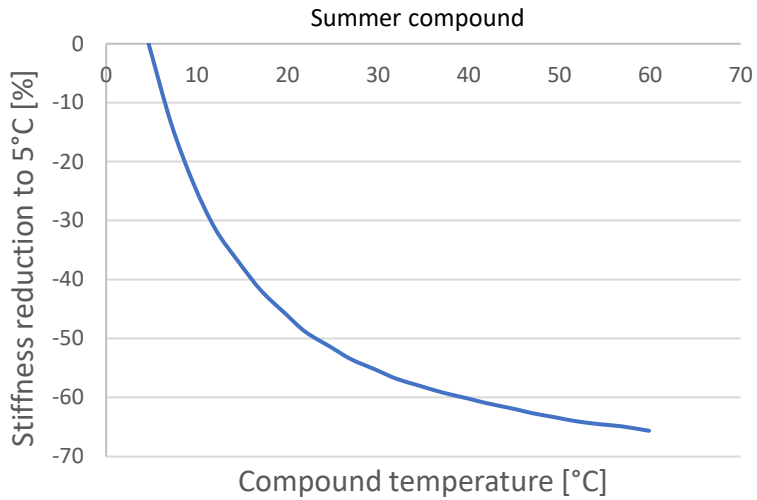
Environmental conditions

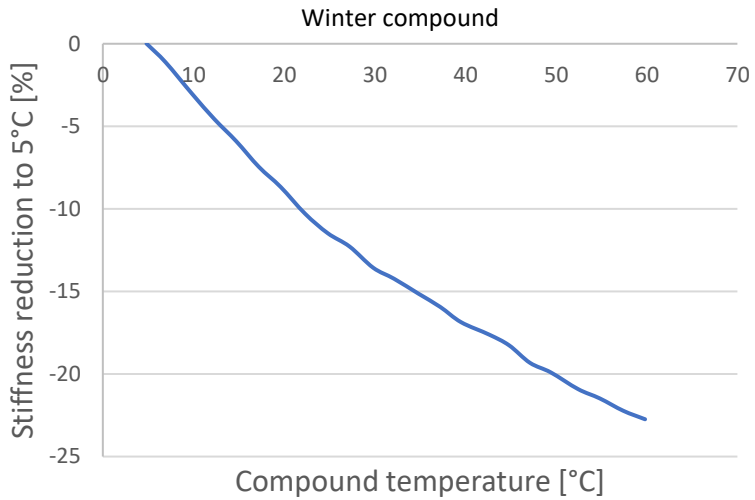


Non linearity of compound stiffness and tyre rolling noise vs. temperature

› **Laboratory tests on rubber samples (no tyre test)** were performed to analyse the dynamic compound stiffness vs. temperature





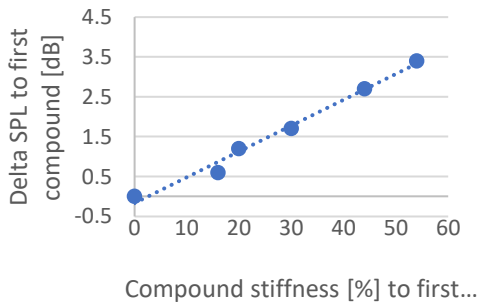


› The analysis of rubber samples shows a non-linear correlation between the compound temperature and its dynamic stiffness

Non-linearity of temperature corrections

Pass-by-Noise

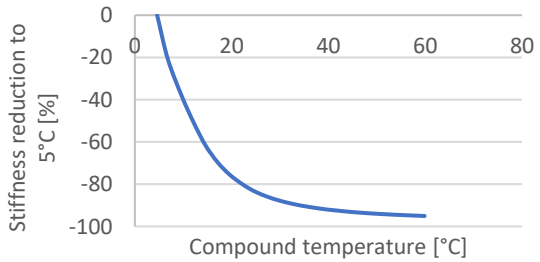
- Linear correlation



Rubber physicals

- Stiffness
- Energy dissipation
- …

- **Non**-linear correlation



Rubber temperature

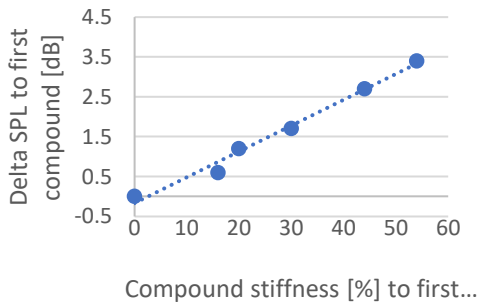
- Correlation possible?

Environmental conditions

Non-linearity of temperature corrections

Pass-by-Noise

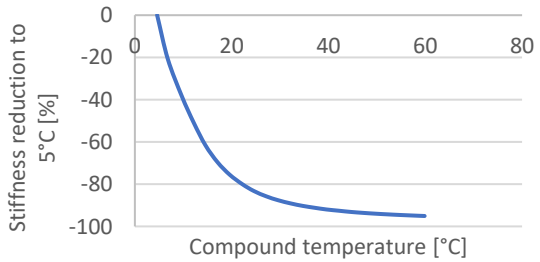
- Linear correlation



Rubber physicals

- Stiffness
- Energy dissipation
- …

- **Non**-linear correlation



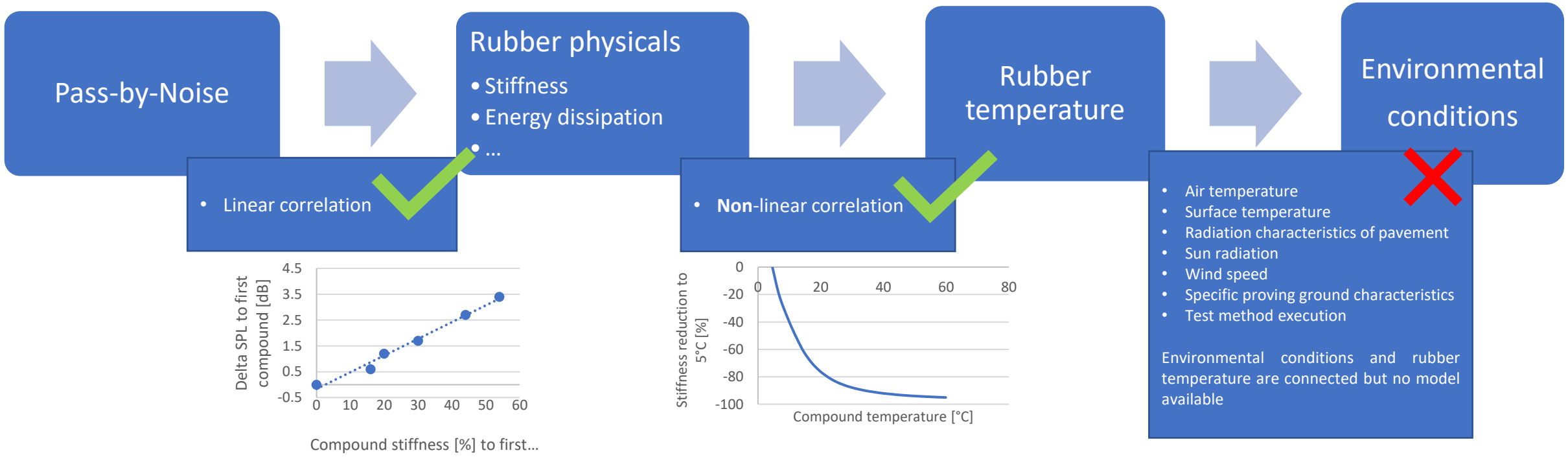
Rubber temperature

Environmental conditions

- Air temperature
- Surface temperature
- Radiation characteristics of pavement
- Sun radiation
- Wind speed
- Specific proving ground characteristics
- Test method execution

Environmental conditions and rubber temperature are connected but no model available

Non-linearity of temperature corrections



› In order to establish a linear correlation between air temperature and tyre rolling noise the correlation between rubber temperature and air temperature would need to compensate the non-linear correlation between rubber physics and rubber temperature

› Based on these results a non-linear interaction between environmental conditions and tyre rolling noise has to be assumed for C1 tyres

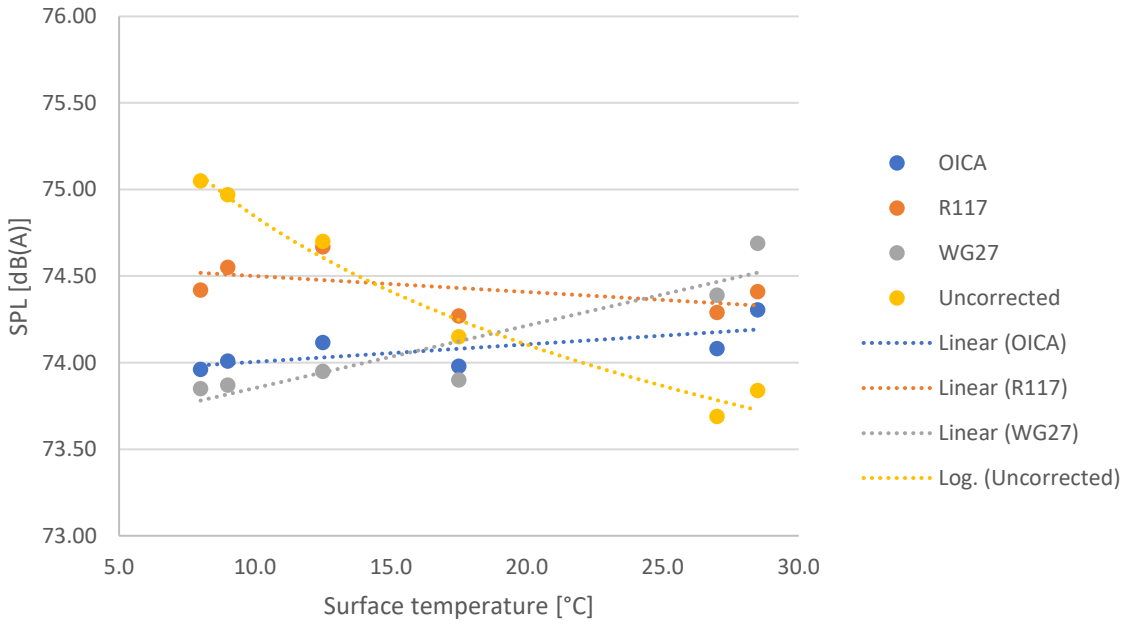
Agenda

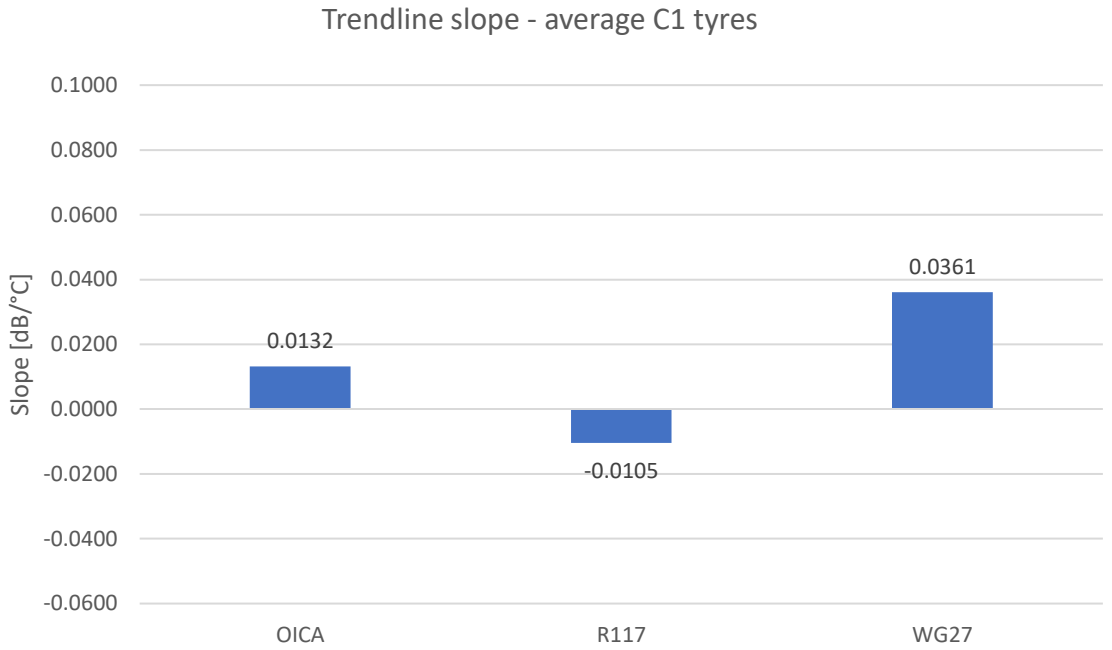
Preliminary trend analysis of proposed temperature correction models regarding R117 and R51.03

- ETRTO started to analyse the proposed temperature correction models using available tyre data from existing measurement campaigns
- Correction formulas were applied to the uncorrected SPL results using either air or surface temperature depending on each model.
- In order to make the correction models comparable the following graphs show all corrected SPL values plotted vs. surface temperature

C1 tyres – Preliminary trend analysis of temperature correction models

› Ten tyres in the size range from 185 to 235 were analysed



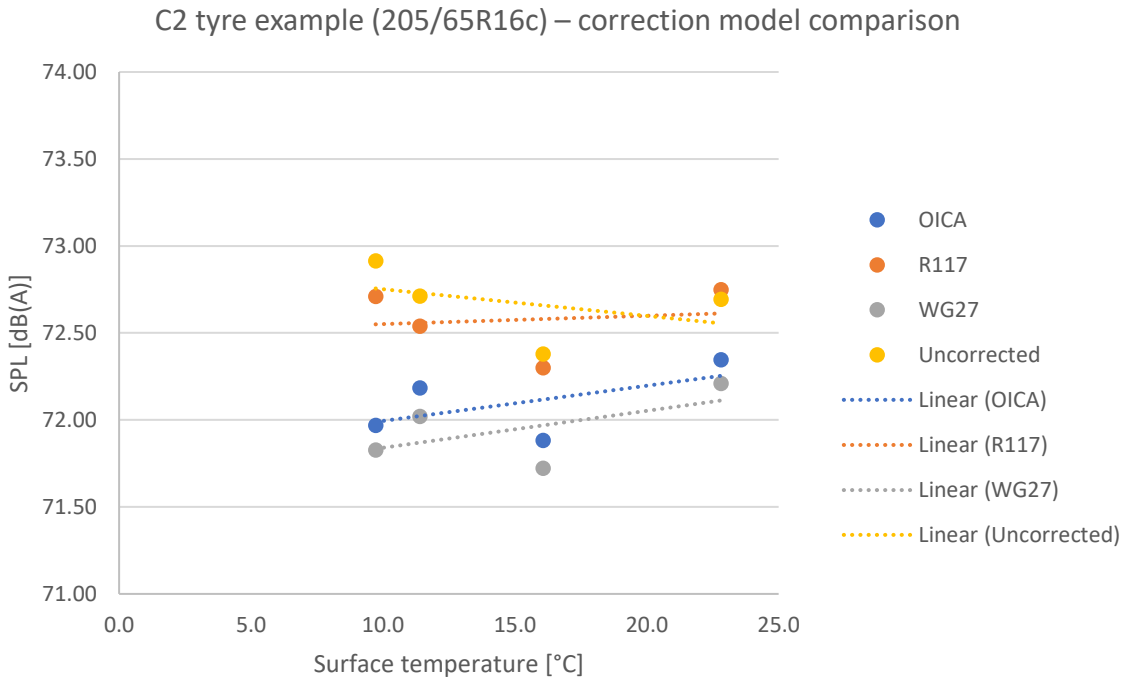


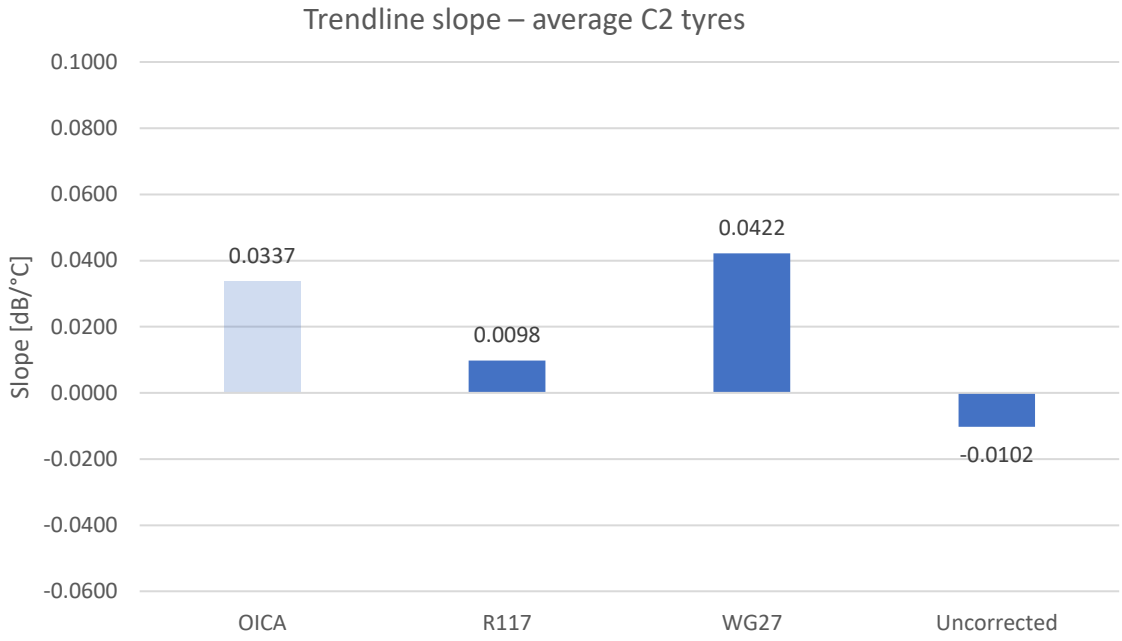
› **Correction models from OICA and R117 successfully detrend the uncorrected data**

› **The correction model proposed by WG27 tends to overcorrect the measurement results**

C2 tyres - Preliminary trend analysis of temperature correction models

› Three tyres in the size 205/65R16c were analysed



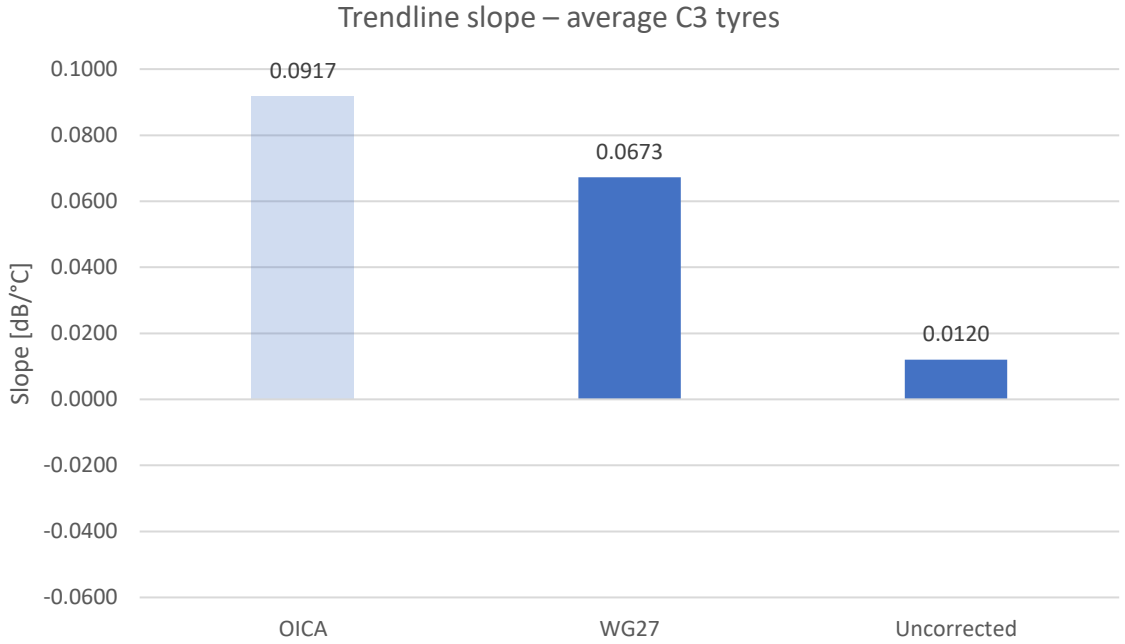


› **For C2 tyres the uncorrected data show a lower temperature sensitivity than C1 tyres**

› **Both the OICA and the WG27 model tend to overcorrect C2 measurement results**

C3 tyres - Preliminary trend analysis of temperature correction models

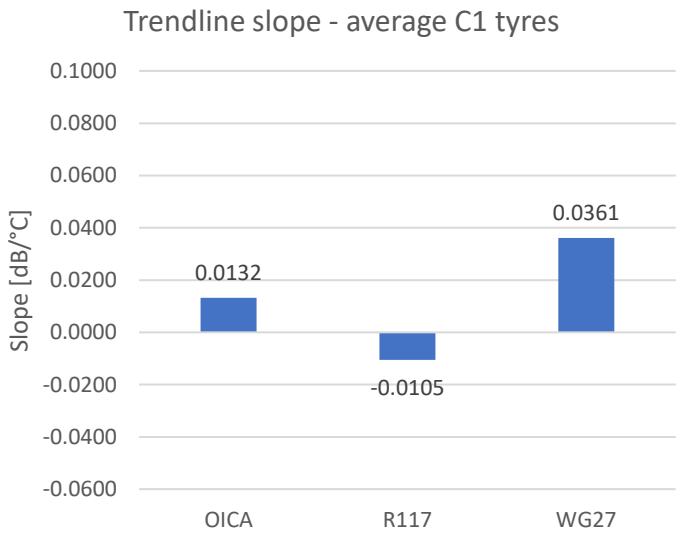
› Three tyres in the size 315/80R22.5 were analysed

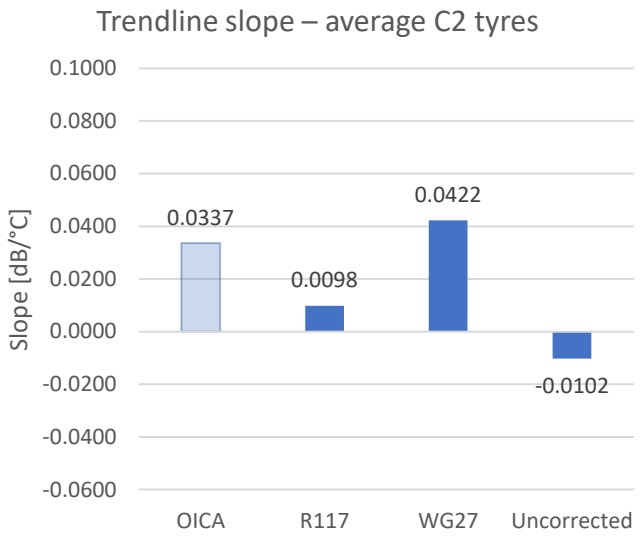


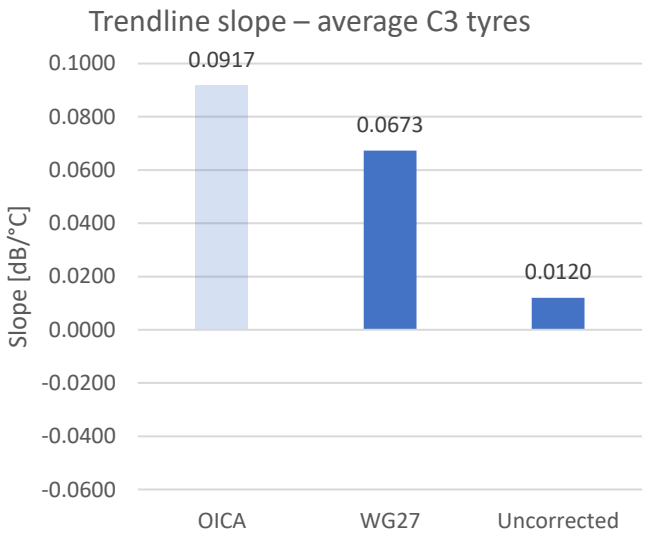
› **For C3 tyres the uncorrected data show a much lower temperature sensitivity than C1 tyres**

› **Both the OICA and the WG27 model tend to overcorrect C3 measurement results**

Preliminary trend analysis of temperature correction models



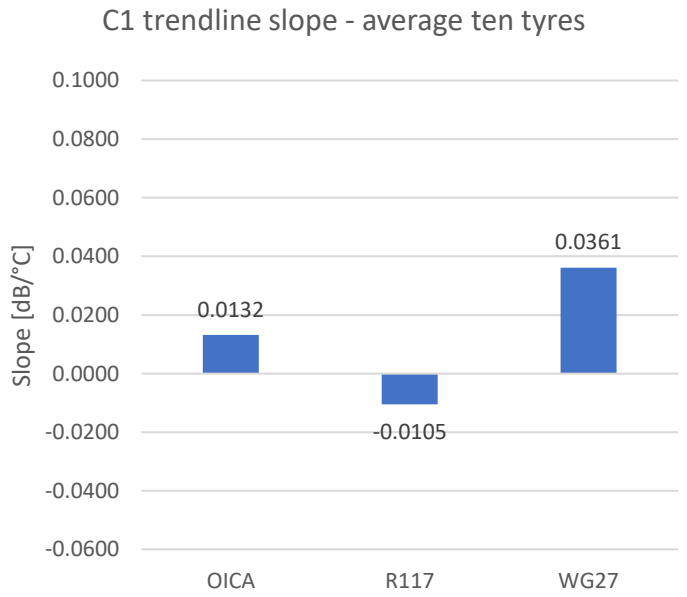




- Regarding the measurement uncertainty for R117 this analysis does not show an advantage by using one of the proposed temperature correction models from OICA or WG27
- ETRTO is aware that the used data would not be statistically sufficient to derive or develop a new temperature correction, however it allows to compare the ranking of the three discussed correction models

Trend analysis of temperature correction models

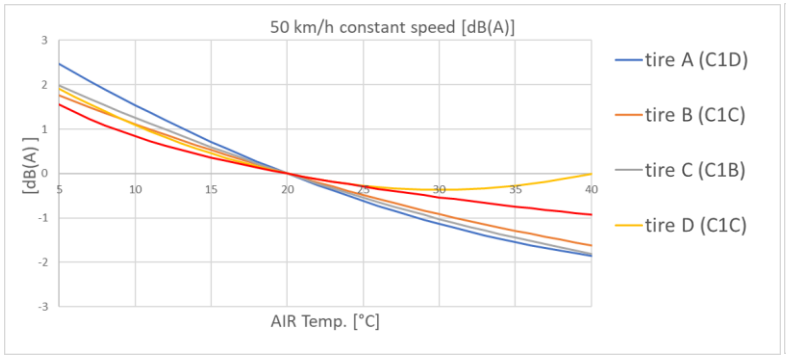
- For C1 tyres the OICA temperature correction model shows a very good result in detrending the temperature effect.
- ETRTO does not opposed the OICA model to be used within R51.03 considering the smaller scope of tyres used for vehicle homologation
- ETRTO has one remark regarding temperature corrections for accelerated measurements at air temperatures above 25°C which is addressed in chapter 1.3.

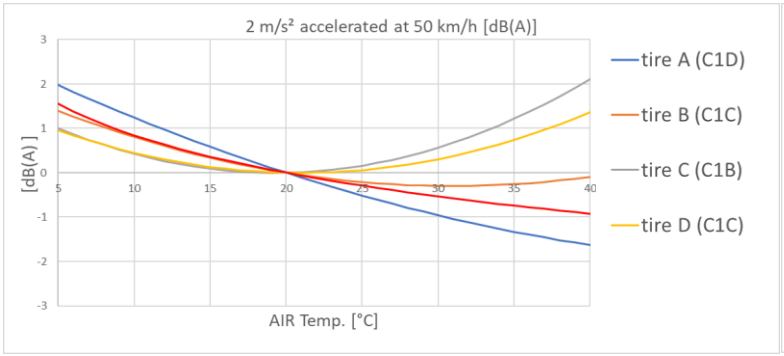


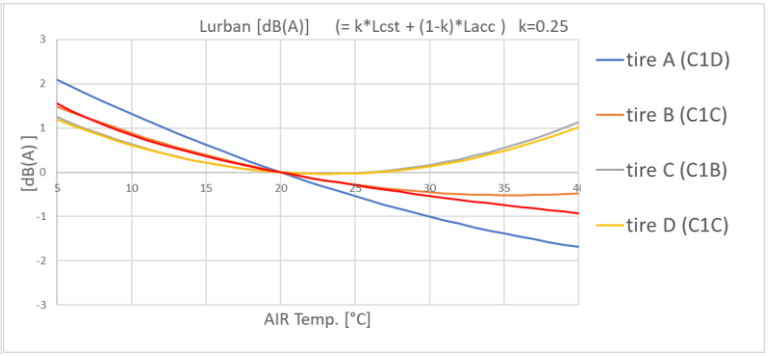
Agenda

R51.03 Accelerated PbN measurements with electric vehicle

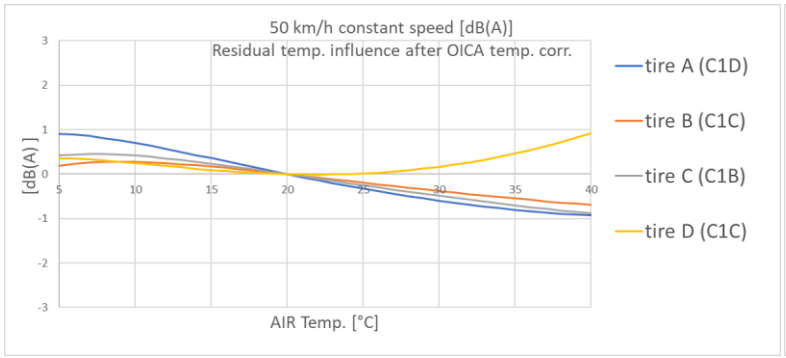
Uncorrected

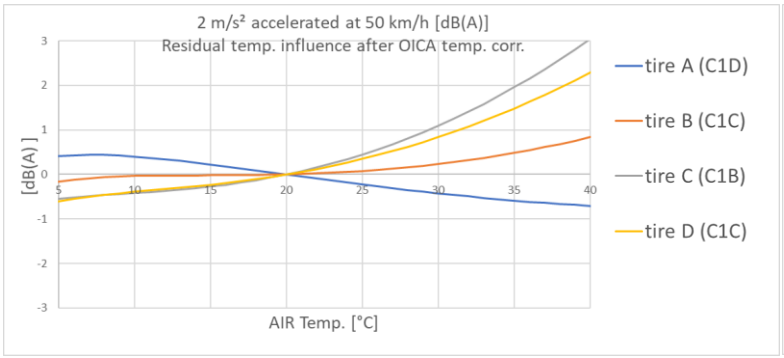


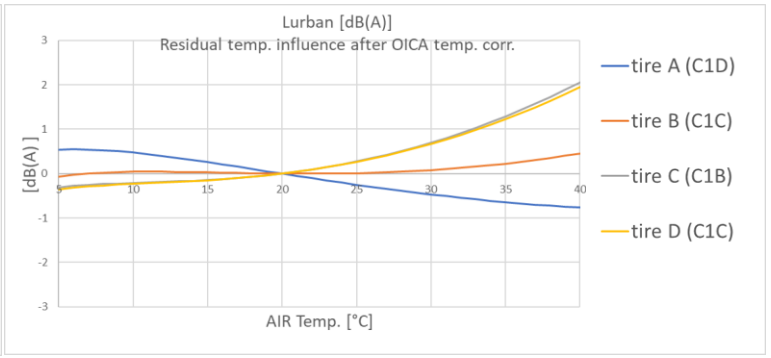




Corrected







- 4 different EU summer tyres (sizes ranging from C1B to C1D) covering the entire range of UN Reg. 51 tyre noise temp. sensitivity (from highest to lowest sensitivity) Noise temp. sensitivity of tyre B and D is representative for most common OE summer tyres
- The proposed OICA temp. correction will reduce measurements uncertainty of the 50 kph constant speed noise for Normal Use (summer) tires
- Regarding accelerated measurements further analysis is required

Agenda

R117 measurements uncertainty table

	Uncertainty categories	Systematic or Random	Standard Uncertainty [dB] 95% confidence interval	Description
1	**Test Repeatability** *(day by day)*	**Random**	**± 0.6** *(b)*	Result variability once tyres, track, acquisition system, vehicle and modus operandi are the same (Day and driver might be different)
1.1	**Test Repeatability** *(run to run)*	**Random**	**± 0.3** *(b)*	Result variability for consecutive test once tyres, track, acquisition system, vehicle and modus operandi are the same
1.2	**Track Humidity**	**Random**	**± 0.3** *(a)*	Alignment with R51.03 proposal
1.3	**Speed effect**	**Random**	**± 0.13**	Minimum requirement for sensor accuracy in R117 is ± 1km/h Tyre noise vs speed sensitivity= 0.2 dB/km/h PtoP =0.2 dB* 2km/h=0.4 dB (± 0.13)
1.4	**Temperature influence C1/C2/C3** *(after temperature correction C1/C2 without temperature correction C3)*	**Random**	**± 0.3** *(b)*	Despite temperature correction a residual error remains. C3 tyre have a lower temperature sensitivity.
2	**Track to Track**	**Systematic**	**± 1.8** *(a)*	Estimated by VDA round robin test results
3	**Tyre to tyre**	**Random**	**± 0.5** *(b)*	Uncertainty due to production variability (Different plants, different period…..) Excluding ageing effect
4	**Sound meter-to sound meter**	**Random**	**± 0.4**	Measurement system shall meet class 1 requirements
5	**Vehicle influence**	**Systematic / Random**	**± 1.0** *(b)*	Possibility to use different vehicles. Uncertainty takes into consideration differences on: Wheel adjustment, Suspension, Tyre load and inflation, Body-road clearance, shadowing and reflecting properties, Rim, Transmission noise, Bearings, Brake noise (brakes not completely released), Body shape - aerodynamic noise around the vehicle body and extra equipment
	Total Uncertainty		**± 2.2 dB**	**Combined standard uncertainty** **$U = \sqrt{(u_1^2+u_2^2+u_3^2+u_4^2+u_5^2)}$**

(a) Values retrieved from third party studies

(b) Based on ETRTO data

- Track humidity added
- Total uncertainty estimated for R117 is aligned with the estimation for R51.03 L_{crs}

Agenda

Preliminary summary

- It was shown that for C1 tyres a non-linear relation between tyre rolling noise and environmental conditions must be assumed
- ETRTO is aware that the available data would not be statistically sufficient to derive or develop a new temperature correction, however it allows to compare the ranking of the three discussed correction models
- The evaluation of the temperature correction models from OICA and WG27 in regards to C1, C2 and C3 tyres for R117 has not shown an improvement in measurement uncertainty compared to the existing temperature correction in R117. Without additional evidence the existing correction should be kept in place for the time being.
- In general, it is assumed by ETRTO that no major improvement regarding measurement uncertainty within R117 for the temperature influence can be achieved at this stage. The possibility to develop a correction formula based on rubber temperature could be explored in the long term.
- For C1 tyres the OICA model shows a very good result in detrending the temperature effect for constant speed measurements. ETRTO is not opposed to the OICA model for use within R51.03 considering the smaller scope of tyres used for vehicle homologation with the remark that the temperature sensitivity of the torque effect will need further investigation to be successfully covered by any temperature correction.

Preliminary summary

- ETRTO proposes to set up the measurement uncertainty table for R117 in alignment with ISO 13325
- The main contributors to the measurement uncertainty are identified
    1. Track-to-track variation
    2. Influence of test vehicle
- The sum of these two uncertainties make 90% of the total uncertainty and can not be addressed in the short term
- Future activities include:
    - **Short term: -** Proposal for the Compensation of tyre aging (to be included in the working document for R117 amendment)

      - Further investigate on the temperature sensitivity of C3 tyres
    - **Mid term (after 2022): -** ISO 20908 indoor drum test

      - Assess track-to-track variation correction and alignment proposals
    - **Long term (min. five years): -** New concept for ISO 10844

      - Investigate concept for possible temperature correction based on rubber temperature

Thank you