ETRTO
The European Tyre and Rim Technical Organisation

ETRTO proposal for R117 C1 noise temperature correction update

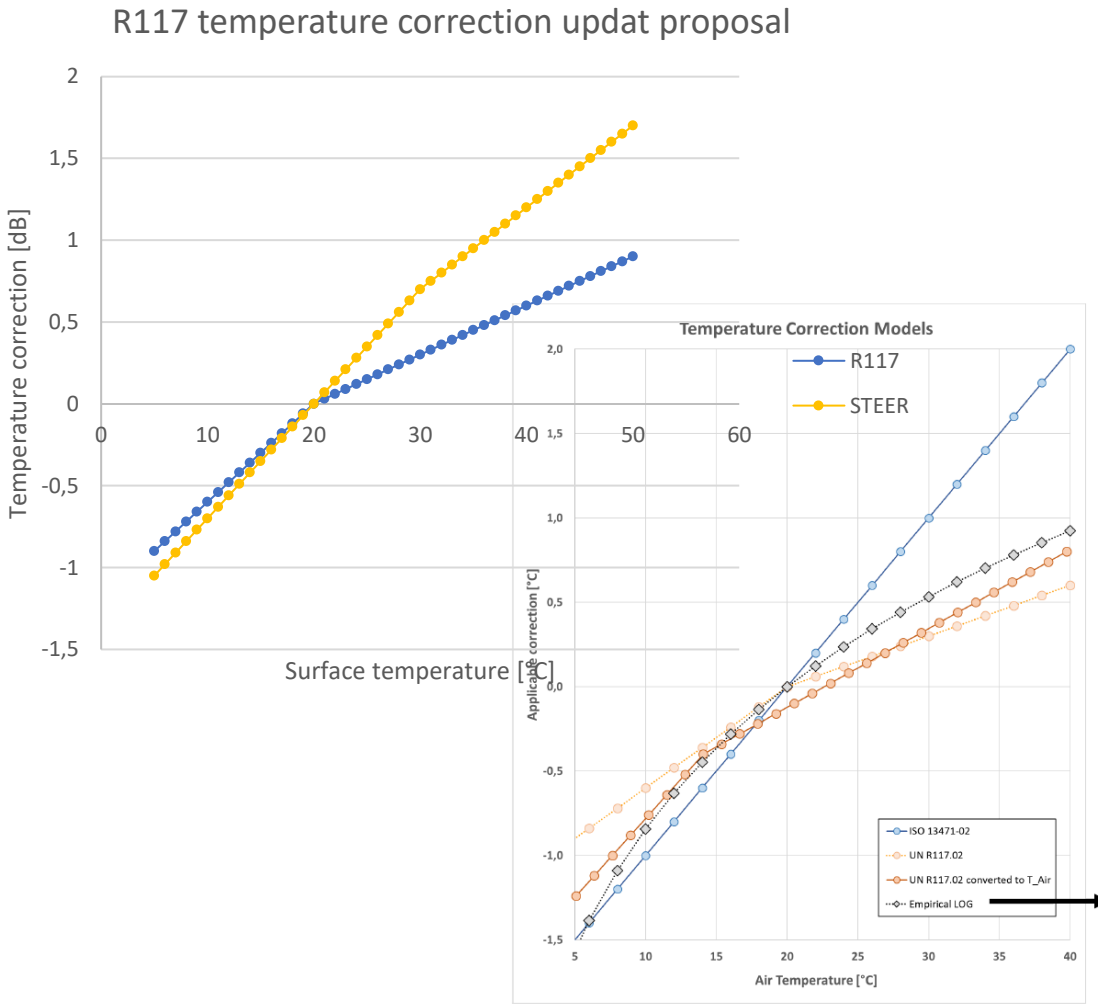
IWGMU Nov. 2022

Agenda

1. Introduction
2. Why not change R117 to air temperature?
3. Temperature sensitivity of C1 normal and 3PMSF tyres
4. Validation
5. Next steps

Update of the R117 C1 temperature correction

- Tyre rolling noise tests results are affected by changes of the rubber stiffness for different temperatures. Even if the temperature sensitivity is not the main source of uncertainty, there is the need to correct the result to consider such temperature dependency.
- Currently there are several temperature correction models in discussion.
- The main differences between these models are related to the measured temperature (surface or air) that they use for the correction, and the slope of the correction at different temperatures.
- **ETRTO collected data to analyze:**
    1. **Potential negative consequences from changing R117 to air temperature.**
    2. **Proposals for improvements of the R117 temperature correction.**



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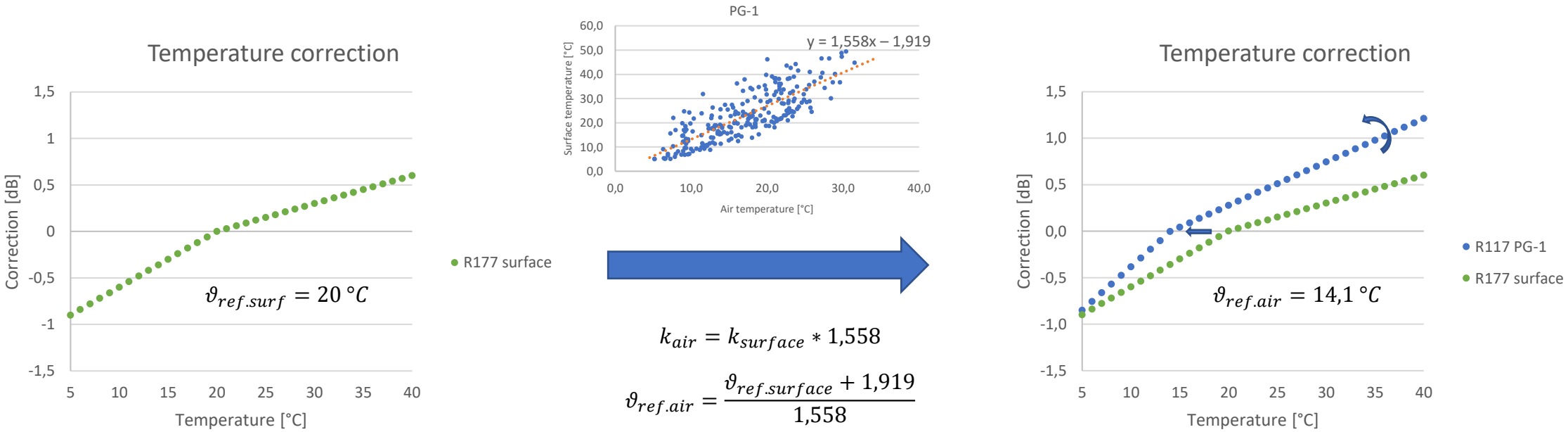
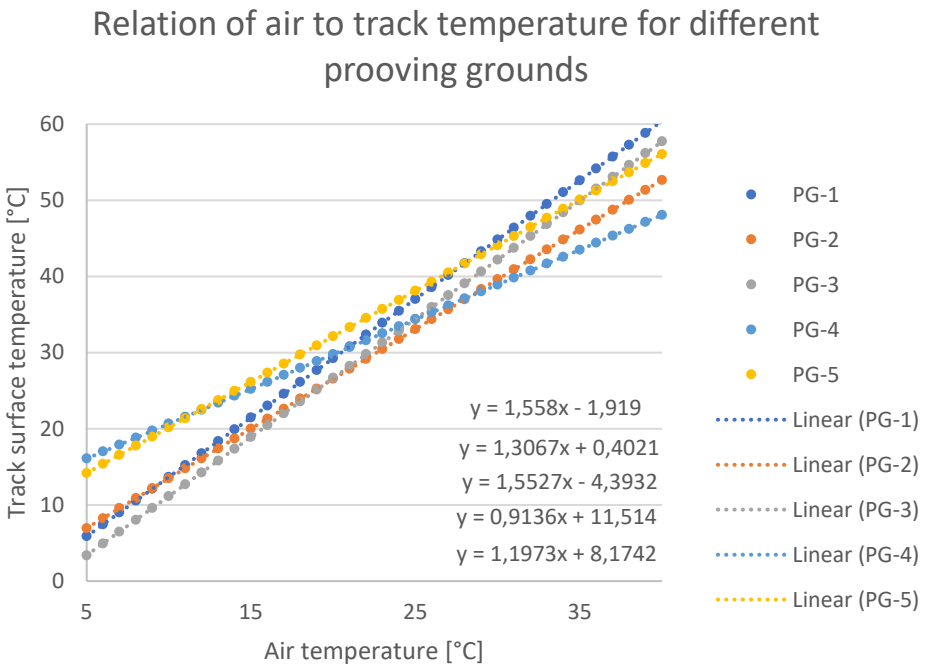
Converting from surface to air temperature



- The conversion of the R117 temperature correction to air temperature if strongly influenced by the proving ground used to determine the T_track / T_air ratio.
- For the presented example of “PG-1” this would result in a new reference temperature for the correction of $\vartheta_{ref.air} = 14{,}1°C$.

Comparison for different proving grounds

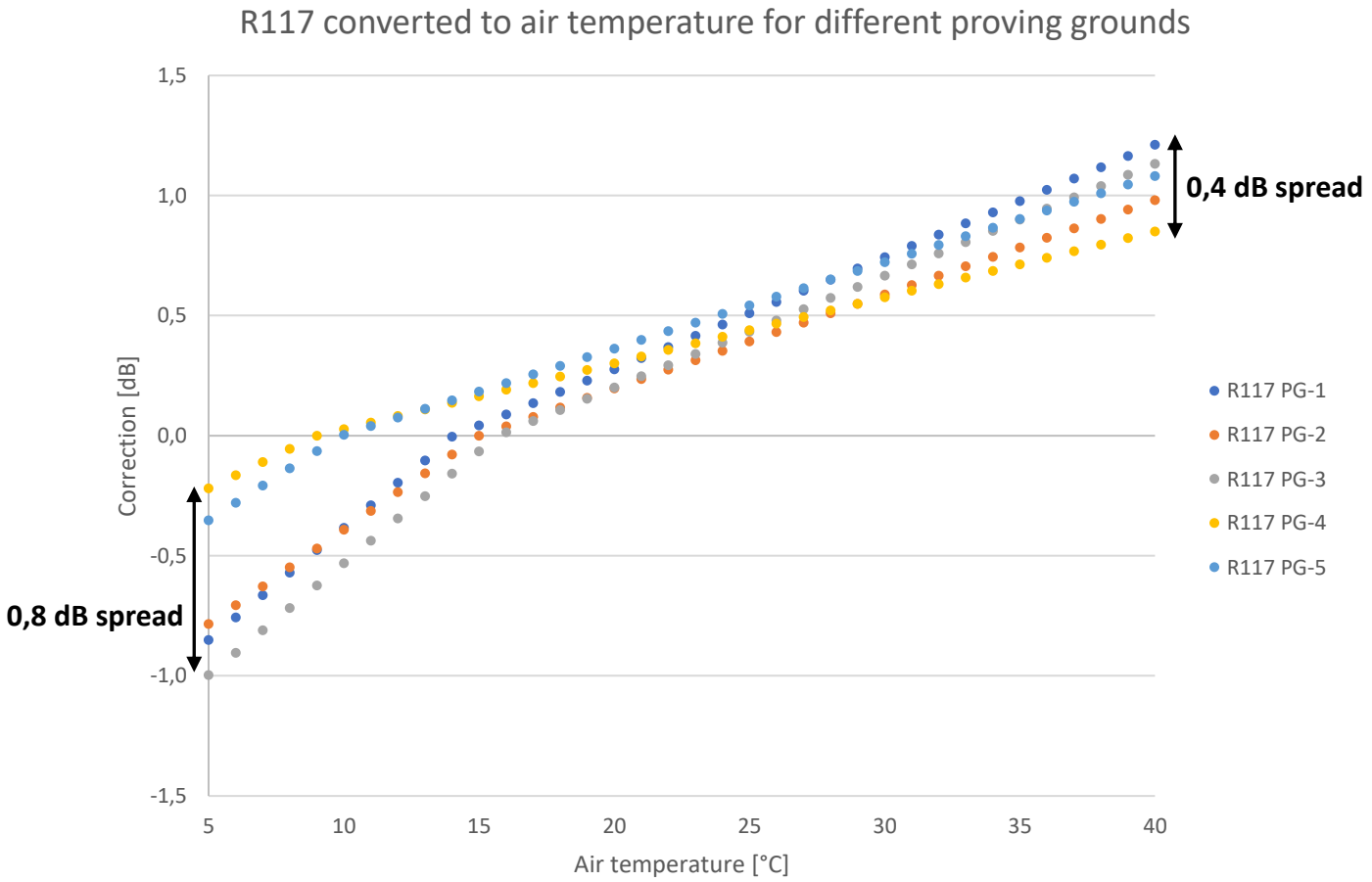


PG	Slope	Offset	$\vartheta_{ref.surface}$	$\vartheta_{ref.air}$
1	1,558	-1,919	20 →	14,1
2	1,3067	+0,4021	20 →	15,0
3	1,5527	-4,3932	20 →	15,7
4	0,9136	+11,514	20 →	9,3
5	1,1973	+8,1742	20 →	9,9

- Slopes and offsets vary significantly for the datasets from only five proving grounds.
- This results in significant changes of the reference temperature and the converted temperature correction for each proving ground.

Comparison for different proving grounds

- Individual corrections are necessary to **keep the same overall noise level of the individual PG**.
- Applying a **generalized conversion** formula would introduce **a new uncertainty** to the overall noise level individually for each proving ground depending on its geographic location.
- ETRTO proposes to **keep the R117** temperature correction **based on the track surface temperature** with updates shown in the next chapter.



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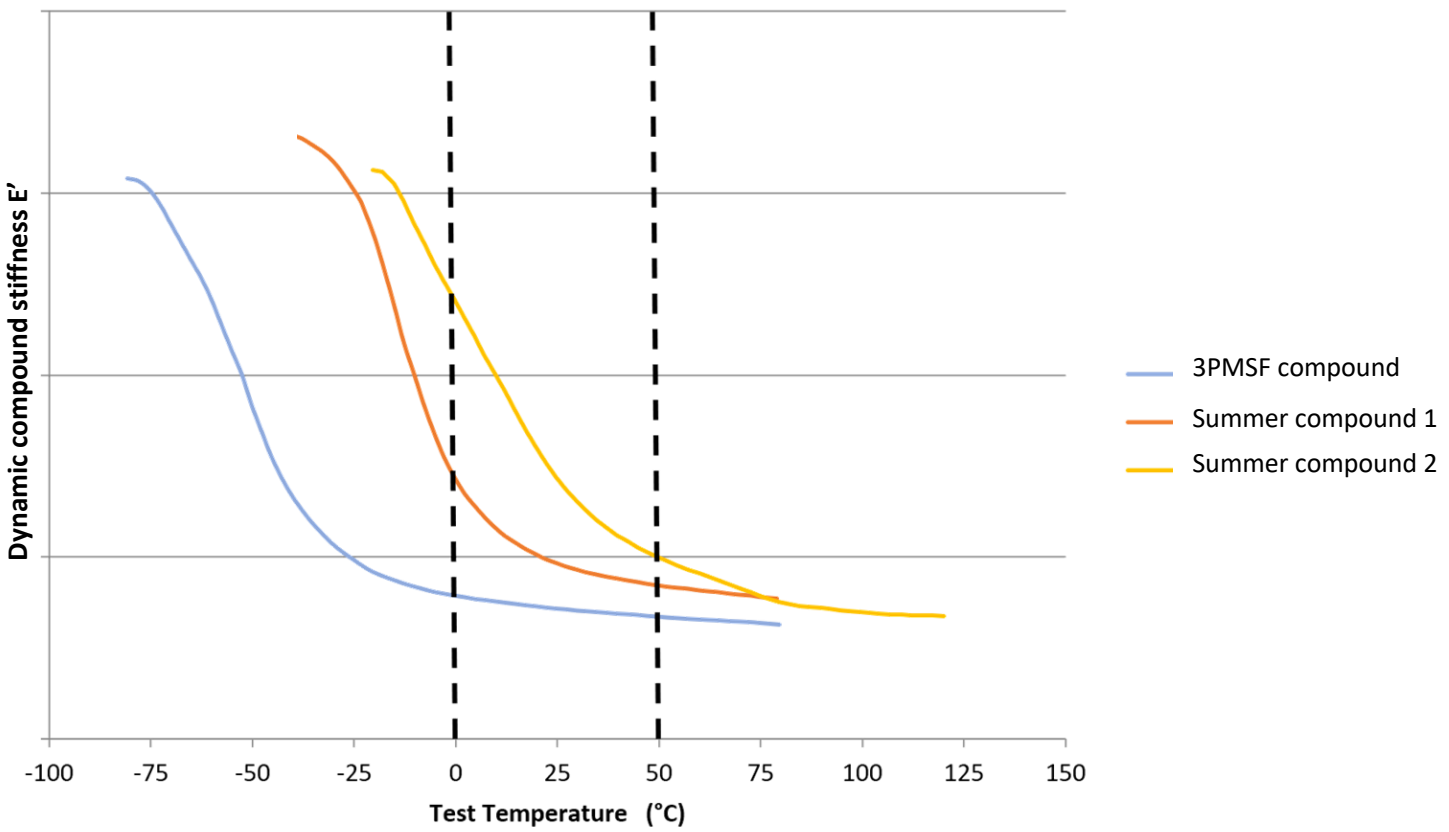
Physical behavior of rubber / Dynamic stiffness E’

- Tyre rolling noise is highly influenced by the stiffness change of the tyre over temperature:
  - Different rubber compounds can show a wide spread of temperature sensitivity regarding their noise performance.
  - One of the main influencing factors is the rubber glass transition temperature.



Verifying and updating the R117 C1 temperature correction

- In general, the available data of R117 measurements with the same tyres at a wide temperature range is very limited and often of a poor correlation between the temperature and the measured rolling noise (e.g., $R^2 < 0{,}5$)
- To improve this situation ETRTO performed 2 activities in parallel:

①

- Proving ground investigation with a high effort to achieve a goal of $R^2 > 0{,}7$ for the correlation between temperature and tyre rolling noise

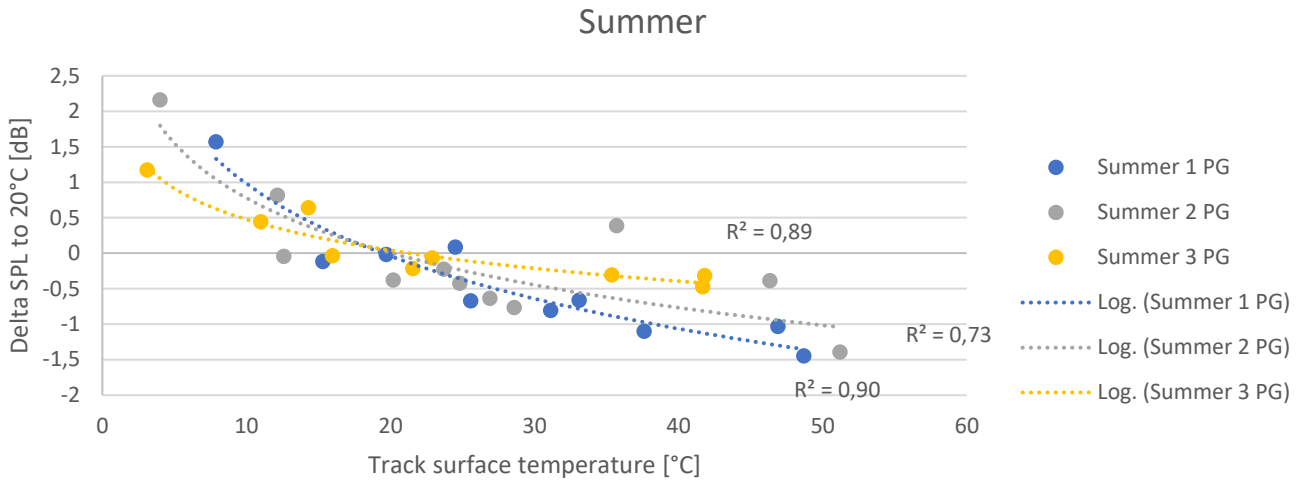
②

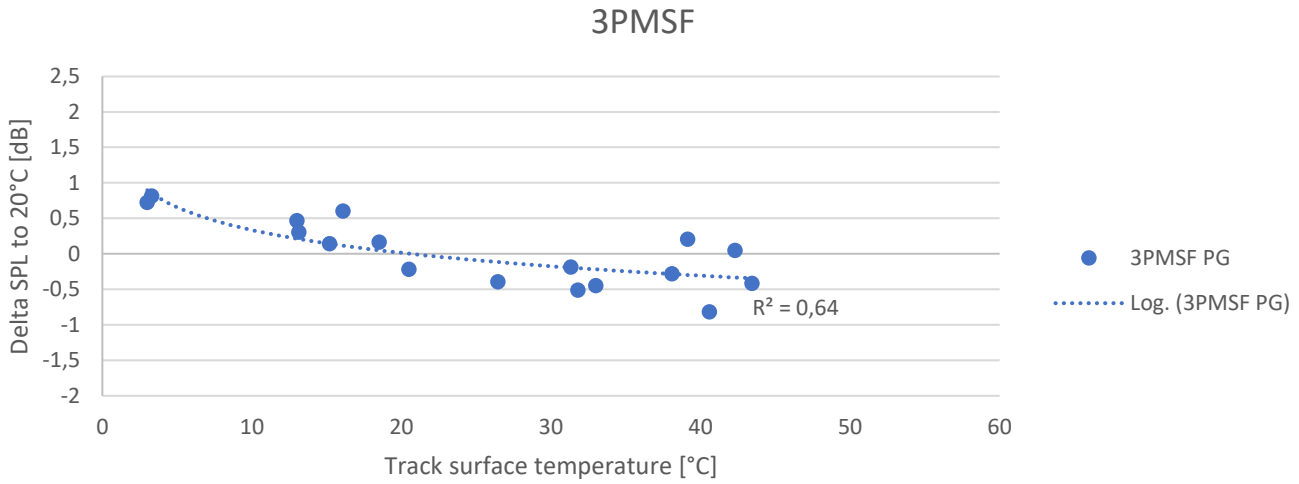
- Experimental drum investigation to exclude as many uncertainties as possible

①

Proving ground investigation

- Three C1 normal tyres and one 3PMSF tyre were tested at different temperatures.
- With the exemption of the 3PMSF tyre, the R^2 of the data is above 0,7.

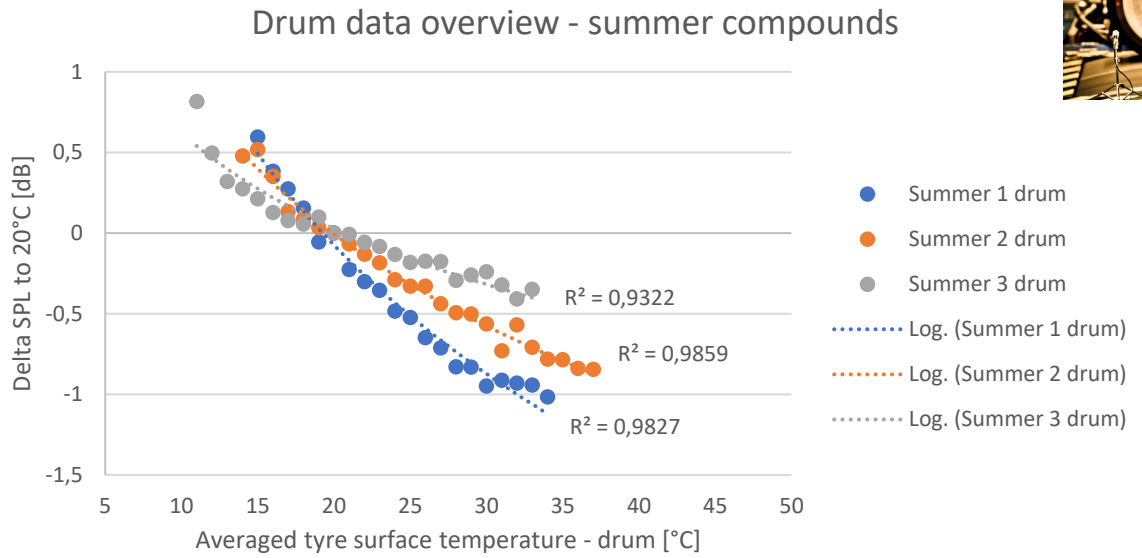


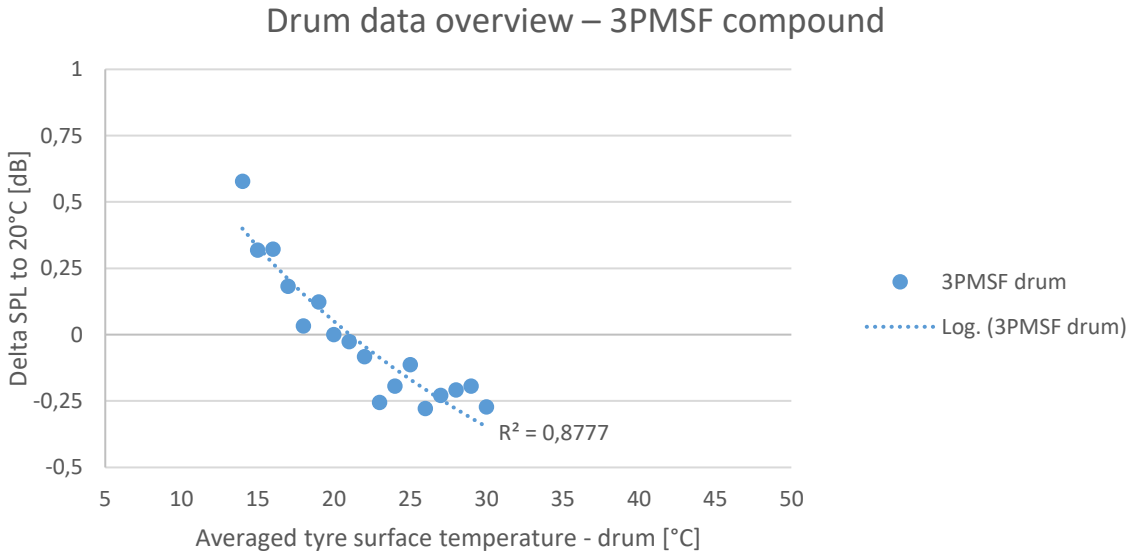


②

Drum investigation

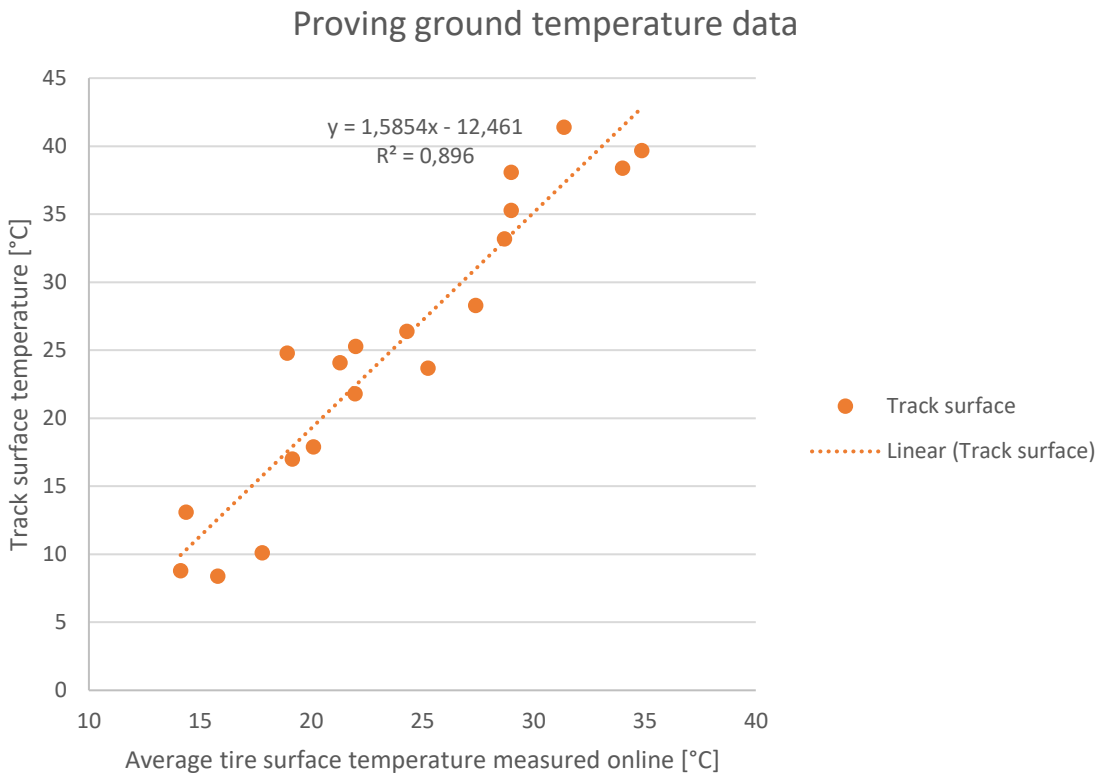
- Four C1 tyres were built with identical pattern and identical construction.
- Changing only the tread compound:
  - **3x summer compounds**
  - **1x 3PMSF compound**
  - Tyres were stored at ambient temperatures < 15°C over night.
- Mounted at the test stand, using an ISO replica drum surface, measuring:
  - tyre rolling noise
  - tyre temperature during the warmup



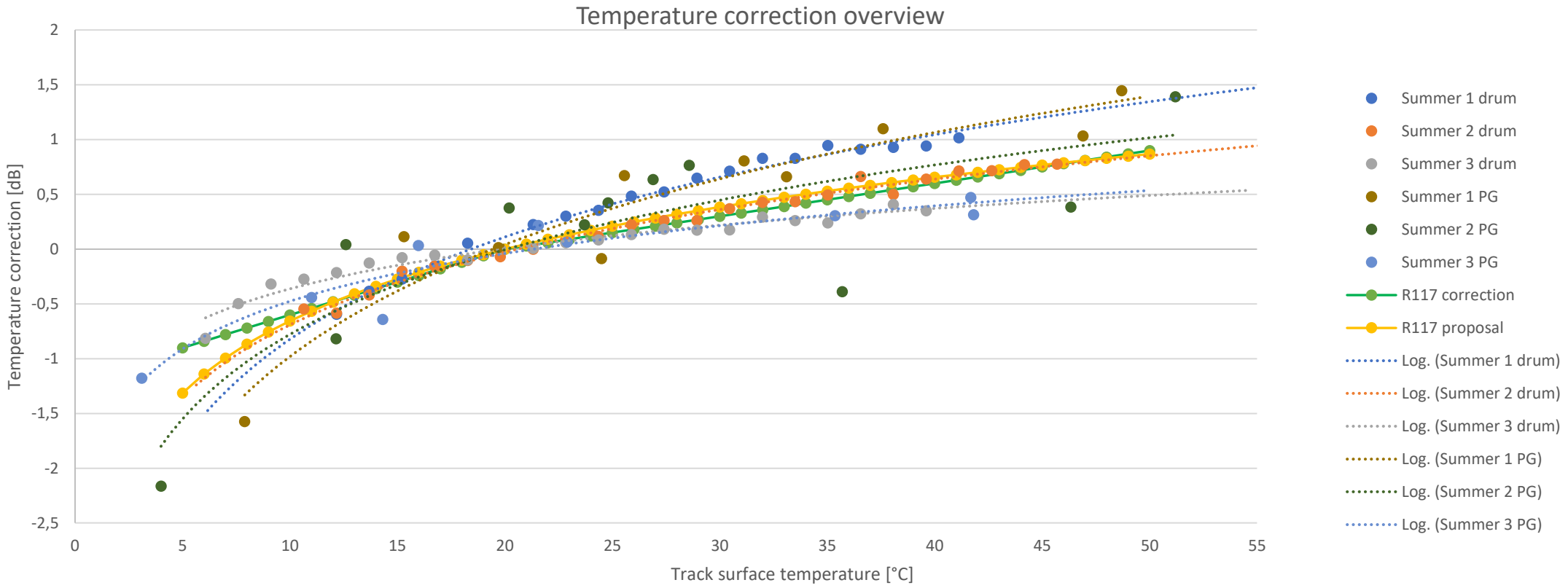


Tyre and surface temperature

- Preliminary data from one proving ground indicates a linear correlation between track surface temperature and average tyre surface temperature measured online in the wheelhouse of the test vehicle.
- This result is used to calculate an equivalent track surface temperature for the indoor tyre temperature data.

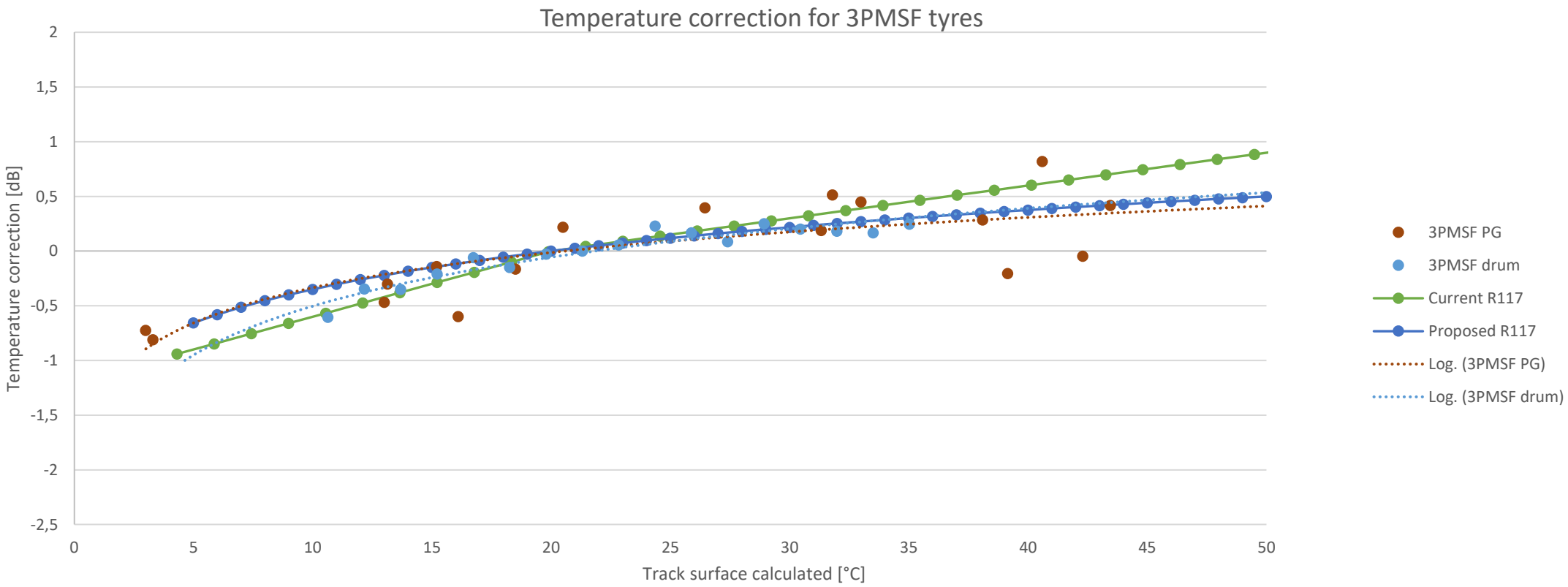


Normal C1 tyre temperature correction



- The current R117 temperature correction is well adapted to cover the average temperature sensitivity of C1 normal tyres.

3PMSF tyre temperature correction

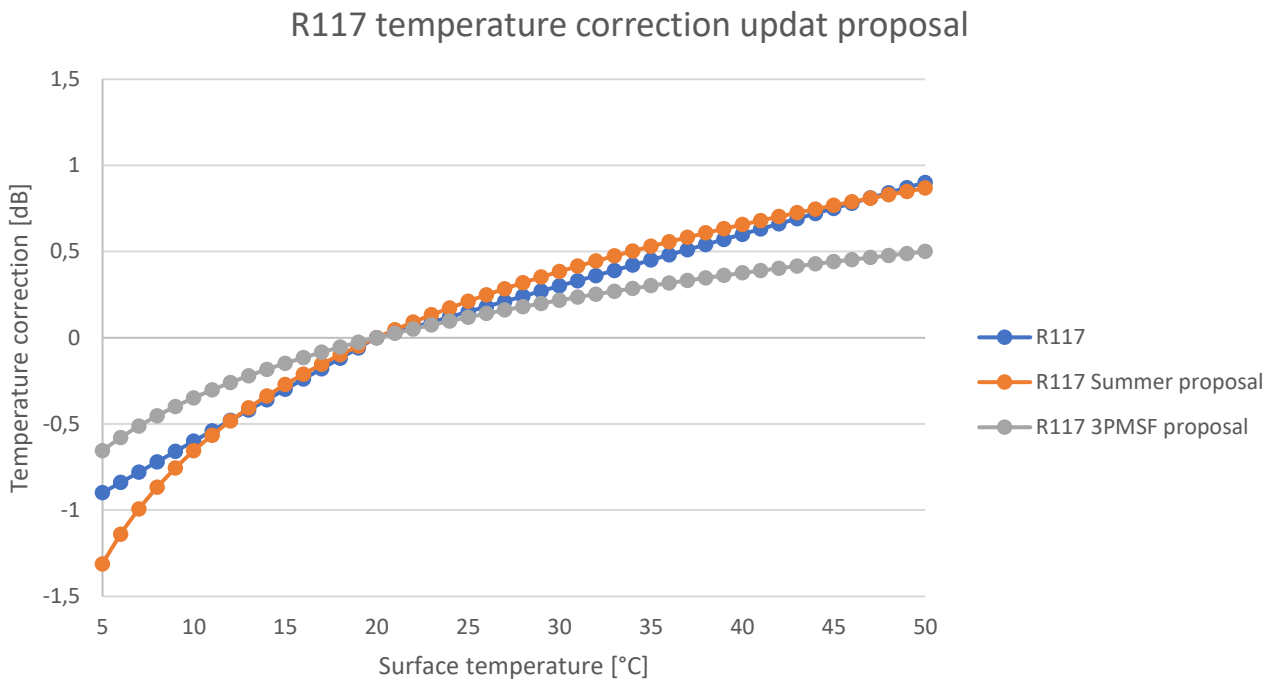


- 3PMSF tyres have a lower temperature sensitivity then summer tyres and are over corrected by the current R117 C1 temperature correction.

Proposal for R117 C1 temperature correction update

$$L_{corr} = -K1 \times LOG\left(\frac{\vartheta_{ref} + K2}{\vartheta_{test} + K2}\right)$$

	Summer	3PMSF
K1	2,18	1,35
K2	0	2,29
ϑ_{ref}	20	20



- The **collected data** from both the proving ground and the drum test **confirm a logarithmic shape** for the temperature correction **as already used in R51**

ETRTO proposal for R117 C1 tyres, based on the collected data:

- **NORMAL TYRES:** the logarithmic shape shall be introduced in R117, by **updating the current correction equation** based on surface temperature
- **3PMSF TYRES: introducing a dedicated logarithmic shape - temperature correction equation,** to better represent the low temperature sensitivity of 3PMSF compounds

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Validation of the proposed C1 temperature corrections

The proposed temperature corrections have been assessed on 15 data sets using the two following metrics:

Standard deviation

	Summer	3PMSF
No temperature correction	0.47	0.28
Current R117	0.32	0.25
Proposed normal tyres LOG	0.32	
Proposed 3PMSF LOG		0.19

Slope regression

	Summer	3PMSF
No temperature correction	0.06	0.026
Current R117	0.031	0.016
Proposed normal tyres LOG	0.028	
Proposed 3PMSF LOG		0.009

The ETRTO proposal reduces the uncertainties for 3PMSF tyres.

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Next steps

- Collect drum data to evaluate the C2 temperature correction.
- Ask for support from ISO regarding the observed proving ground variations and data collection for a discussion in the next revision cycle of ISO 10844.
- Continue the investigations regarding the connection between tire, air and surface temperature.

ETRTO
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Thank you!