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PRESENTATION OF

INTERNATIONAL ORGANIZATION OF MOTOR VEHICLE MANUFACTURERS

# Proposal for a Temperature Correction for C2 Tyres in UN R51.03

## Informal Working Group on Measurement Uncertainty #14
## 11. October 2021

# Objective

- Draft Supplement 8 considers a temperature correction for UN R51.03 Annex 3 test under acceleration and constant speed for vehicles of category M1, N1 and for vehicles of category M2 with a gross vehicle mass not exceeding 3.500kg.

- The prime consideration was, that these vehicle use only tyres of category C1 according to the definition of UN R117. Hence the main focus was on these tyres.

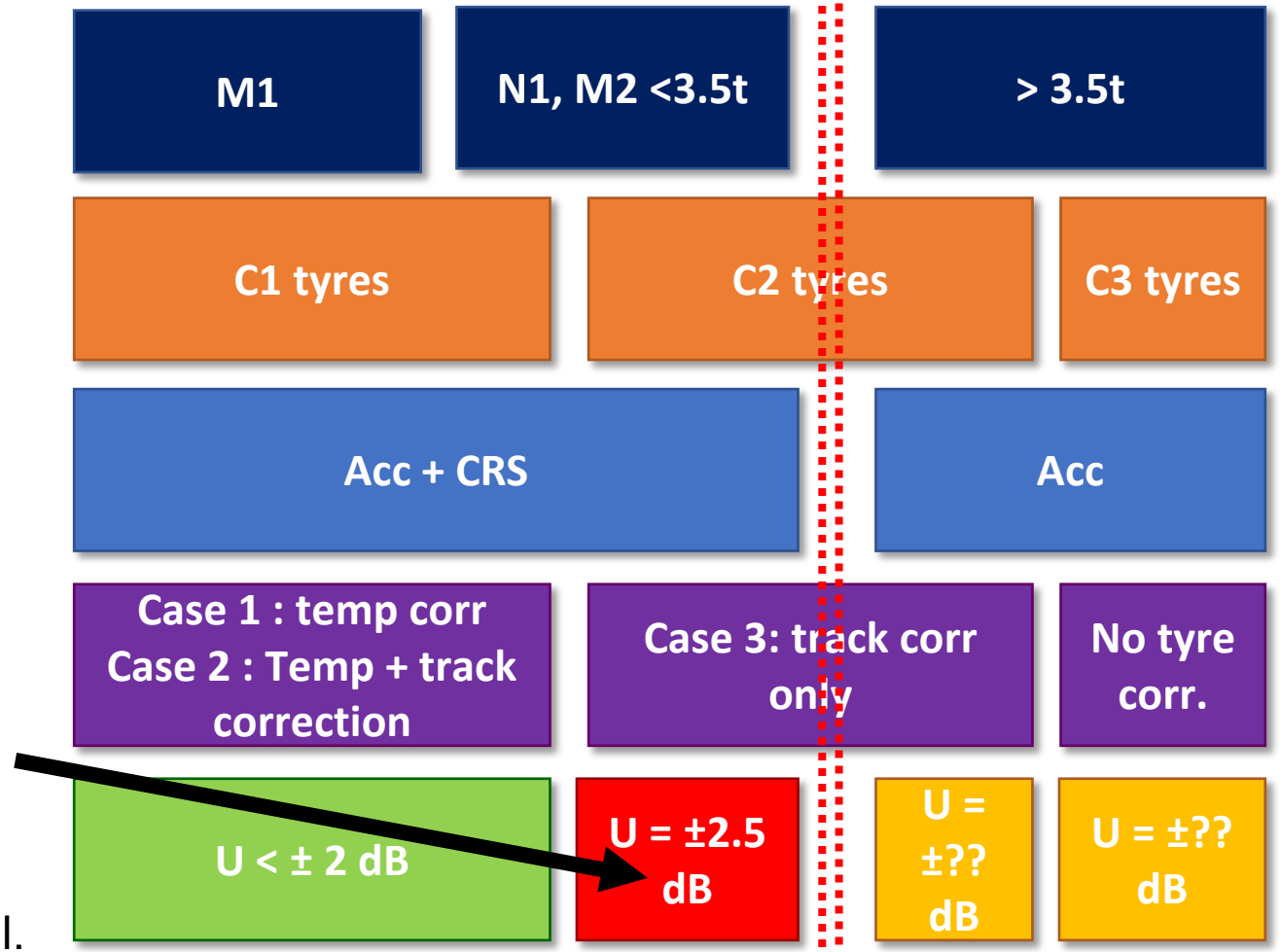
- Meanwhile it has become obvious, that within the UN R51.03 Annex 3 test procedure as well C2 tyres are used, especially for N1 vehicles. At the moment, for C2 tyres only a test track compensation is considered.

- This presentation is an approach to extend the temperature compensation strategy as developed for C1 tyres as well to C2 tyres.

# Current Status on temperature correction for tyre sound emission

The tyre/rolling sound is a major source for sound emission, especially under constant speed test

In case of C2 tyres, the measurement uncertainty by tyres/rolling sound and test track can be improved, by implementing a temperature correction for C2 tyres as well.




Out of scope, as the test method is at a rather low speed and the power train is dominant.
The Uncertainty coming from tyres is less than 2 dB(A)

# Current Status on temperature correction for tyre sound emission

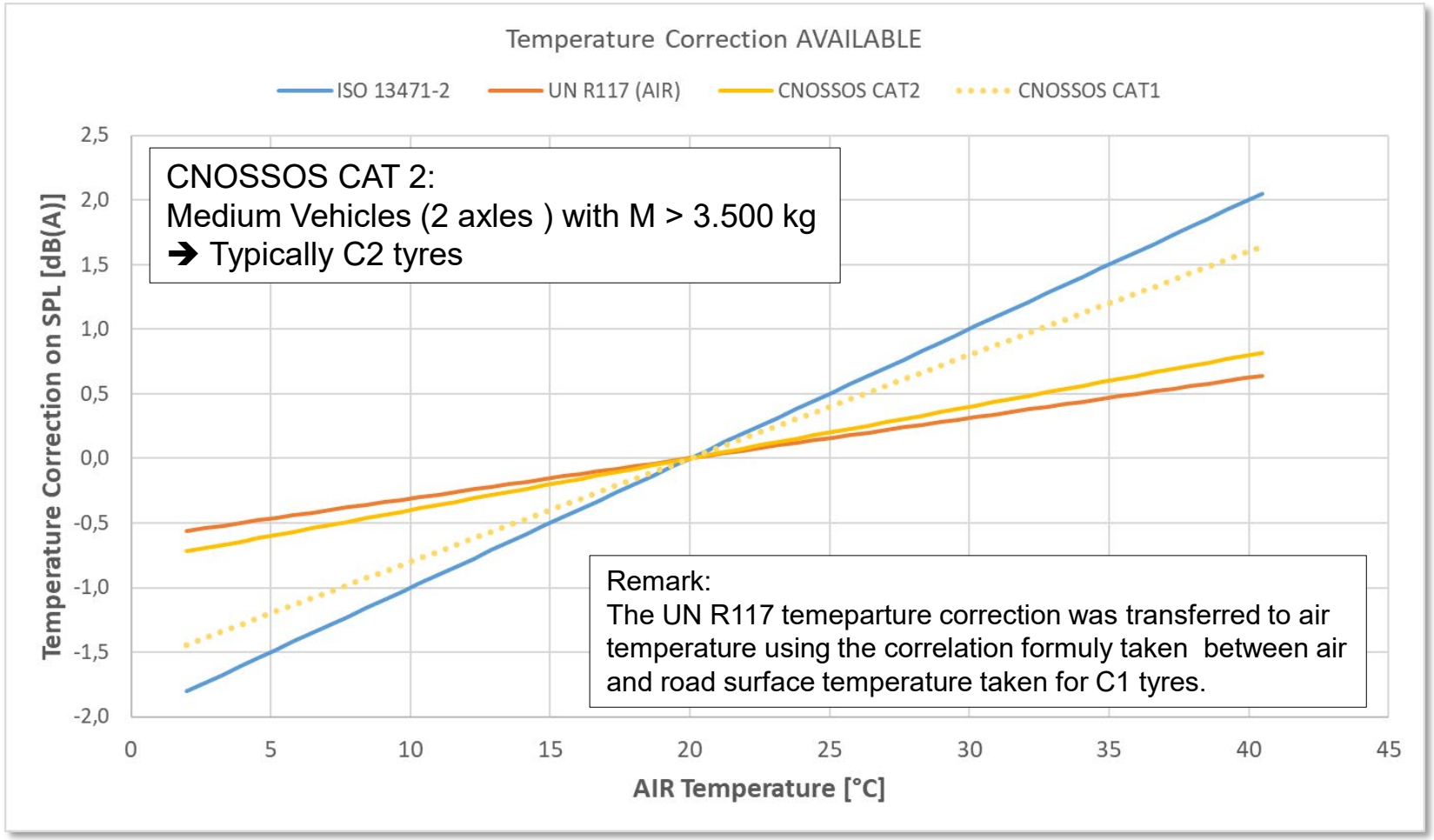
| Situation | Input Quantity | estimated deviations of the meas. result (peak-peak) | | Impact on Lurb | Probability Distribution | Variance | Standard deviation | Share [%] | Combined standard uncertainty |
|---|---|---|---|---|---|---|---|---|---|
| | | Lwot | Lcrs | | | | | | |
| Run to Run | Micro climate wind effect | 1.60 | 1.50 | **1.57** | gaussian | 0.15 | 0.392 | 5.1% | 0.53 |
| | Deviation from centered driving | 0.50 | 0.50 | **0.50** | rectangular | 0.02 | 0.144 | 0.7% | |
| | Start of acceleration | 0.60 | 0.00 | **0.40** | rectangular | 0.01 | 0.114 | 0.4% | |
| | Speed variations of +/- 1km/h | 0.50 | 0.50 | **0.50** | rectangular | 0.02 | 0.144 | 0.7% | |
| | Load variations during cruising | 0.00 | 1.00 | **0.34** | gaussian | 0.01 | 0.085 | 0.2% | |
| | Varying background noise | 0.40 | 0.40 | **0.40** | rectangular | 0.01 | 0.115 | 0.4% | |
| | Variation on operating temperature of engine and tyres | 0.80 | 0.80 | **0.80** | rectangular | 0.05 | 0.231 | 1.8% | |
| Day to Day | Barometric pressure (Weather +/-30 hPa) | 0.70 | 0.00 | **0.46** | gaussian | 0.01 | 0.116 | 0.4% | 0.92 |
| | Air temperature effect on tyre noise (5-10°C) | 0.00 | 0.00 | **0.00** | rectangular | 0.00 | 0.000 | 0.0% | |
| | Air temperature effect on tyre noise (0-40°C) | 2.20 | 3.60 | **2.67** | rectangular | 0.60 | 0.772 | 20.0% | |
| | Varying background noise during measuremnt | 0.00 | 0.00 | **0.00** | rectangular | 0.00 | 0.000 | 0.0% | |
| | Air intake temperatuire variation | 1.60 | 0.00 | **1.06** | rectangular | 0.09 | 0.305 | 3.1% | |
| | Residual humidity on test track surface | 0.90 | 2.10 | **1.31** | rectangular | 0.14 | 0.377 | 4.8% | |
| Site to Site | Altitude (Location of Test Track) 100 hPa/1000m | 0.70 | 0.00 | **0.46** | rectangular | 0.02 | 0.134 | 0.6% | 1.24 |
| | Test Track Surface | 3.40 | 5.50 | **4.11** | rectangular | 1.41 | 1.187 | 47.3% | |
| | Microphone Class 1 IEC 61672 | 1.00 | 1.00 | **1.00** | gaussian | 0.06 | 0.250 | 2.1% | |
| | Sound calibrator IEC 60942 | 0.50 | 0.50 | **0.50** | gaussian | 0.02 | 0.125 | 0.5% | |
| | Speed measuring equipment continuous at PP | 0.10 | 0.10 | **0.10** | rectangular | 0.00 | 0.029 | 0.0% | |
| | Acceleration calculation from vehicle speed measurement | 0.50 | 0.50 | **0.50** | rectangular | 0.02 | 0.144 | 0.7% | |
| Vehicle to Vehicle | Production Variation Tyre and aging of tyres | 0.80 | 1.50 | **1.04** | gaussian | 0.07 | 0.259 | 2.3% | 0.57 |
| | Production Variation in Power | 0.40 | 0.40 | **0.40** | rectangular | 0.01 | 0.115 | 0.4% | |
| | Battery state of charge for HEVs | 0.00 | 0.00 | **0.00** | rectangular | 0.00 | 0.000 | 0.0% | |
| | Production Variability of Sound Reduction Components | 1.10 | 0.00 | **0.73** | gaussian | 0.03 | 0.182 | 1.1% | |
| | Impact of variation of vehicle mass | 1.60 | 1.60 | **1.60** | rectangular | 0.21 | 0.462 | 7.2% | |

| situation | Input Quantity {Uncertainty of vehicle sound emission} | For indoor | Type B: Deviations of the meas. result (peak-peak) Lwot | probability distribution | variance | standard deviation | contribution [%] | Type B Conbined standard uncertainty |
|---|---|---|---|---|---|---|---|---|
| Run to run | 1) Micro climate wind effect – head wind and tail wind | | 0 | gaussian | 0,000 | 0,000 | 0,0% | 0,3 |
| | 2) Deviation from centered driving | | 0,5 | rectangular | 0,021 | 0,144 | 3,8% | |
| | 3) Speed at BB' – Target vehicle speed (+/-5 km/h), (target engine speed (+/-2%) | x | 0,4 | rectangular | 0,013 | 0,115 | 2,4% | |
| | 4) Varying background noise | x | 0,1 | gaussian | 0,001 | 0,025 | 0,1% | |
| | 5) Warming up routines between runs – operating temperature of engine and tyres (WOT) ==> See ISO 362-1 NOTE | x | 0,8 | rectangular | 0,053 | 0,231 | 9,7% | |
| Day to day | 6) Ambient temperature influence on sound transmission in air (variability in impedance) | | 0,6 | rectangular | 0,030 | 0,173 | 5,5% | 0,5 |
| | 7) Ambient barometric pressure influence on sound transmission in air | x | 0,9 | rectangular | 0,068 | 0,260 | 12,3% | |
| | 8) Ambient humidity influence on sound transmission in air | | 0,1 | rectangular | 0,001 | 0,029 | 0,2% | |
| | 9) Ambient air temperature influence on engine power (based on R85) | | 1,0 | rectangular | 0,083 | 0,289 | 15,2% | |
| | 10) Ambient air temperature effect on ICE vehicles due to tyre noise (5-10°C) | x | 0,4 | rectangular | 0,013 | 0,115 | 2,4% | |
| | 11) Barometric pressure effect on engine power (based on R85) | x | 0,4 | rectangular | 0,013 | 0,115 | 2,4% | |
| Site to site | 12) Altitude effect on combustion and sound propagation (Range: 1000 m) (95-105 kPa ) | x | 0,9 | rectangular | 0,068 | 0,260 | 12,3% | 0,5 |
| | 13) Test Track Surface | x | 1,3 | gaussian | 0,106 | 0,325 | 19,3% | |
| | 14) Microphone Class 1 IEC 61672 | x | 1 | gaussian | 0,063 | 0,250 | 11,4% | |
| | 15) Sound calibrator IEC 60942 | x | 0,5 | gaussian | 0,016 | 0,125 | 2,8% | |
| | 16) Speed measuring equipment continuous at BB | x | 0,1 | gaussian | 0,001 | 0,025 | 0,1% | |
| V to Vehicle | 17) Tyre – generic dispersion (Normal, tread depth, inflation pressure, model etc) *** | | 2,8 | gaussian | 0,490 | 0,700 | | 0,7 |
| | 18) Test mass – variation as a consequence of the definition | | | gaussian | 0,000 | 0,000 | | |
| | 19) Battery state of charge for HEVs | | | gaussian | 0,000 | 0,000 | | |
| COP | 20) Production variability | | | gaussian | 0,000 | 0,000 | | |
| Third party testing | 21) Residual surface humidity | | | rectangular | 0,000 | 0,000 | | |
| | 22) Tyre (Traction, 3PMSF) | | | gaussian | 0,000 | 0,000 | | |

Test Procedure for light vehicle (M1 and M1)

Test Procedure for heavy vehicle (M2, M3, N2, N3)

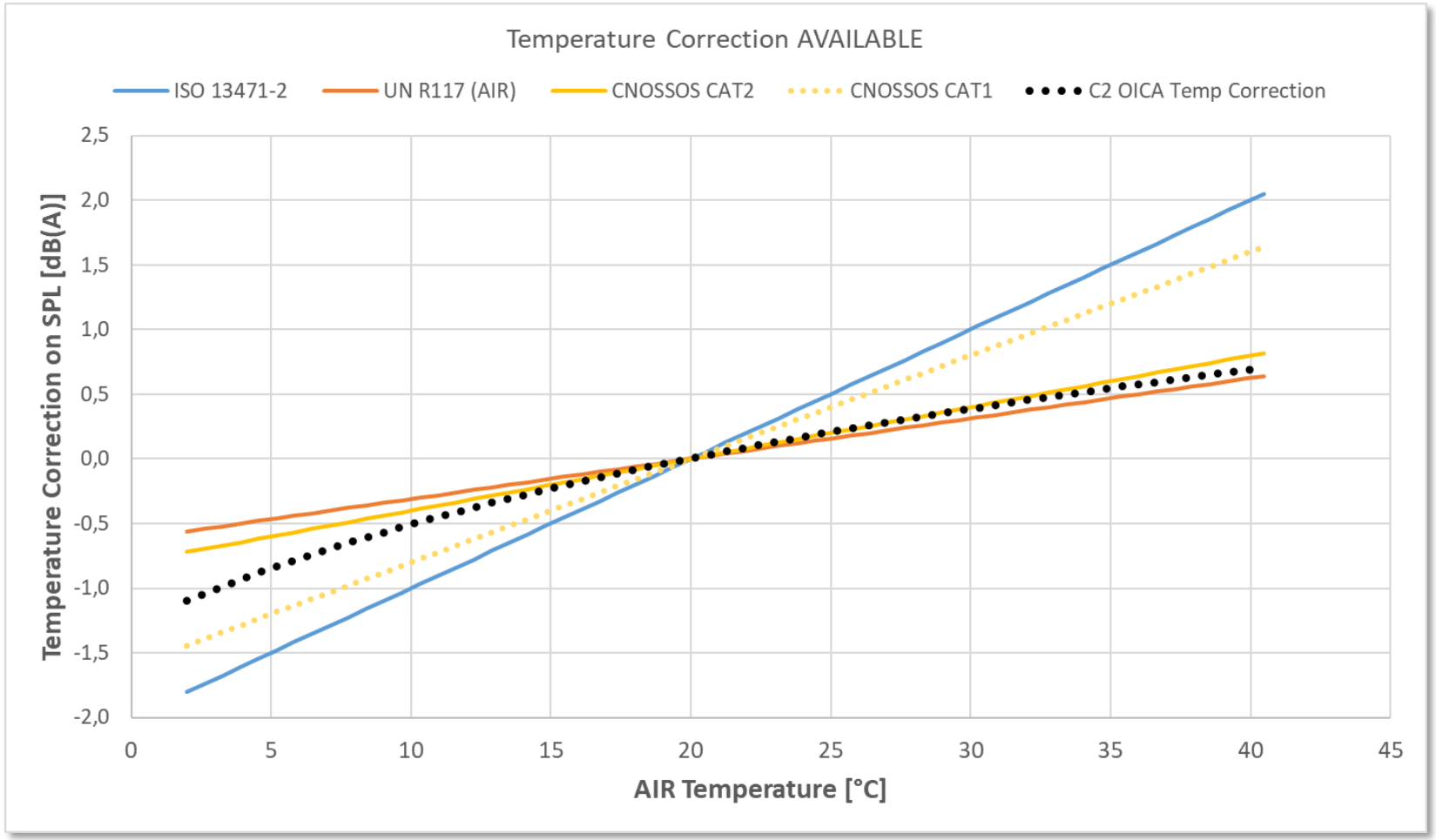
# Temperature Correction for C2 Tyres – Literature Study




There are several temperature corrections available. Most recent curves suggest a correction based on the air temperature (ISO 13471-2 and CNOSSOS).

The temperature sensitivity of C2 tyres is typically less than for C1 tyres, therefore the rolling sound compensation should be less than for C1 tyres.

# Temperature Correction for C2 Tyres – Approach

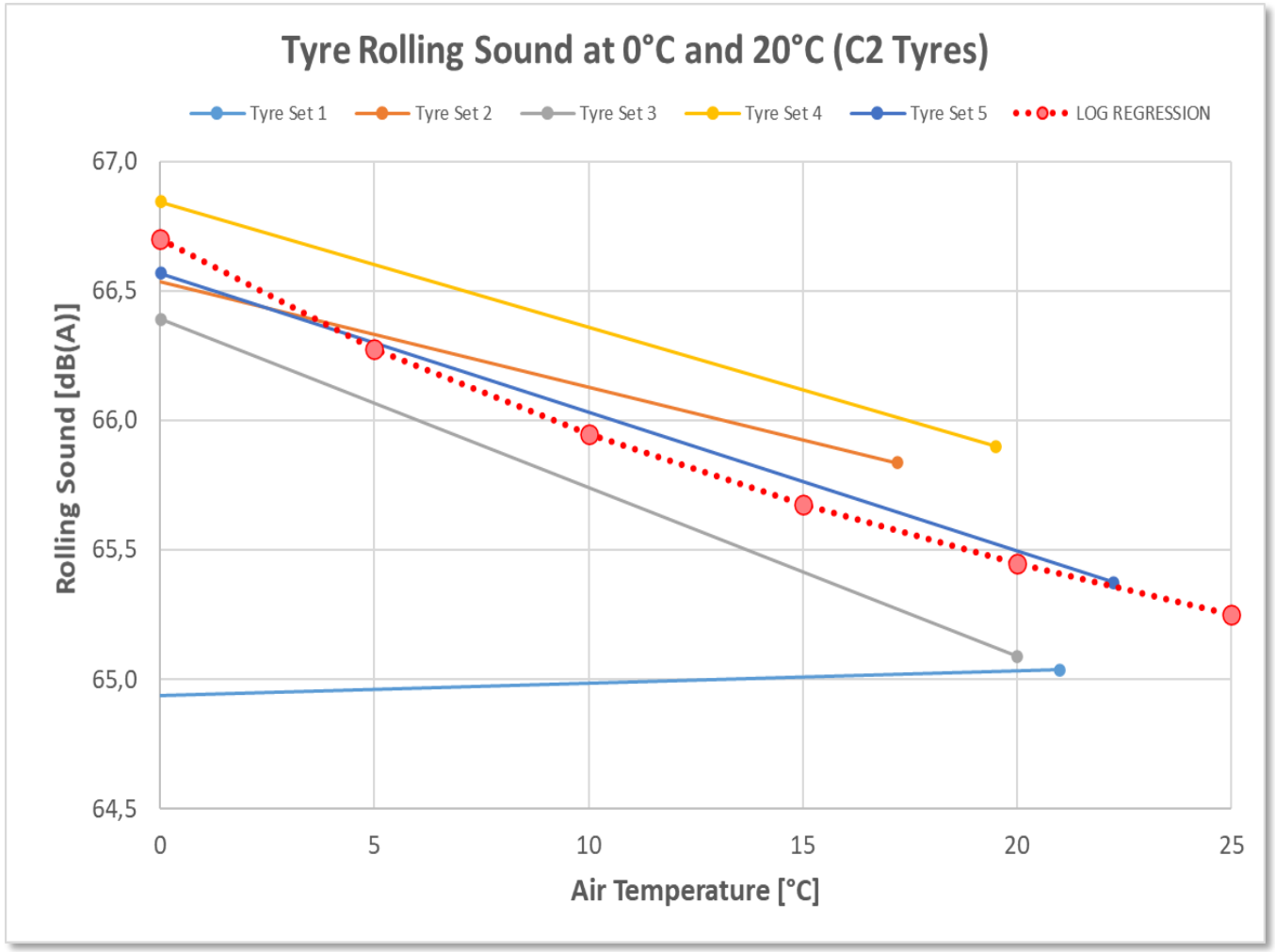



The suggested curve (dotted black) fits well with the CNOSSOS correction for CAT2 vehicles and correlates with the road surface based temperature correction of UN R117.

The logarithmic shape lead to an under-compensation at higher temperatures. In opposite, it is a bit favorable at very low temperatures where the rubber compound might stiffen.

The compensation is much less than for C1 tyres, as in the C2 segment the compound are different and are often closer to All Season tyres.

# Temperature Correction for C2 Tyres – Validation by DATA




The suggested temperature correction allows, that the concept of temperature and test track correction for C1 tyres and be applied to C2 tyres as well.

The correction formula is the same:

$$L_{TR,n,\vartheta REF} = L_{TR,n} + K_1 \times lg\left(\frac{\vartheta_{TEST} + K_2}{\vartheta_{REF} + K_2}\right)$$

The Parameter $K_1$ and $K_2$ differ for C1 and C2 tyres:

| Parameter | C1 Tyres | C2 Tyres |
|---|---|---|
| $K_1$ | 3,4 | 3,4 |
| $K_2$ | 3,0 | 15,0 |