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The selection of new reference test tyres for use with the CPX method, to be specified in ISO/TS 11819-3

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ABSTRACT

The draft for ISO standard ISO 11819-2:2000 for CPX tyre/road noise measurements includes specifications for a set of four standard reference test tyres. These commercially available tyres were selected to cover the different mechanisms responsible for the generation of tyre/road noise. Three were chosen to be representative of passenger car tyres and one to be representative of heavy vehicle tyres. Since the draft standard was first written, these tyres have either been superseded or discontinued. It has therefore been necessary for ISO/TC 43/SC 1/WG 33 (Measuring Methods for Comparing Traffic Noise on Different Road Surfaces), the Working Group responsible for the Standard, to define recommendations for an updated set of reference tyres, at the same time considering whether fewer tyres could be used. This paper provides a summary of the recommendations for the new reference tyres and an overview of the review process which formed the basis of the recommendations, presenting specific results from the evaluation of candidate replacements for ISO tyre A.

1. INTRODUCTION

The draft for ISO standard ISO 11819-2:2000 for CPX tyre/road noise measurements[1] includes specifications for a set of four standard reference test tyres. These commercially available tyres were selected to cover the different mechanisms responsible for the generation of tyre/road noise. Three (referred to as ISO tyres A, B and C) were chosen to be representative of passenger car tyres and one (referred to as ISO tyre D) to be representative of heavy vehicle tyres.

However, since the draft standard was first worked out, these tyres have either been superseded or discontinued. It has therefore been necessary for ISO/TC 43/SC 1/WG 33 (Measuring Methods for Comparing Traffic Noise on Different Road Surfaces), the Working Group responsible for the Standard, to define recommendations for an updated set of reference tyres, at the same time considering whether fewer tyres could be used.

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This document provides a summary of the recommendations for the new reference tyres and an overview of the review process which formed the basis of the recommendations, including specific results from the evaluation of candidate replacements for ISO tyre A.

2. RECOMMENDATIONS FOR NEW REFERENCE TYRES

The following recommendations have been prescribed by WG 33

- It is considered that four reference tyres are no longer necessary for effective application of the CPX method. This means that the investigatory method described in the current draft standard will no longer be applicable
- For general assessments of road surfaces and conformity-of-production (COP) assessment in accordance with procedures such as described in the EU project SILVIA[2], only a single mandatory reference tyre is required. This replaces the current ISO tyre A. For other purposes, a second tyre (which replaces the current ISO tyre D) may be required
- The proposed replacement for tyre A, which will be the mandatory tyre for performing measurements in accordance with the Standard, is a Uniroyal Tigerpaw 225/60 R16 tyre, referred to in this and supporting research documents as ‘tyre A6’. This is used in the automotive industry as a standard reference test tyre and is specified in ASTM F2493-06[3]. Thus, it is also sometimes referred to as the "ASTM" tyre or the SRTT ("Standard Reference Test Tyre") as is used as a term in the ASTM standard. It should not be confused with an older ASTM (SRTT) tyre, which has a rim diameter of 14"
- The proposed replacement for tyre D is the Avon Supervan AV4 195-R14C tyre, referred to in this and the supporting research documents as ‘tyre D4’. It may also sometimes be referred to as the "AV4" tyre

A. Inclusion of the new tyres in ISO 11819

It is proposed that the current draft standard, which includes the old tyre specifications, will be revised and split into two parts as follows:

- ISO 11819:2 (Acoustics — Measurement of the influence of road surfaces on traffic noise — Part 2: The close-proximity method) will cover the test procedure and equipment requirements, and will be adopted as a regular ISO standard
- ISO/TS 11819:3 (Acoustics — Measurement of the influence of road surfaces on traffic noise — Part 3: Reference tyres) will define the test tyres specified above and will be adopted as a Technical Specification (TS)

The expected timetable for this is currently being agreed.

3. BACKGROUND TO THE RECOMMENDATIONS

The following sections provide a brief overview of some of the work undertaken to arrive at the recommendations, focusing only on acoustic performance, and the subsequent review by WG 33. Full details can be found in the individual cited reports.

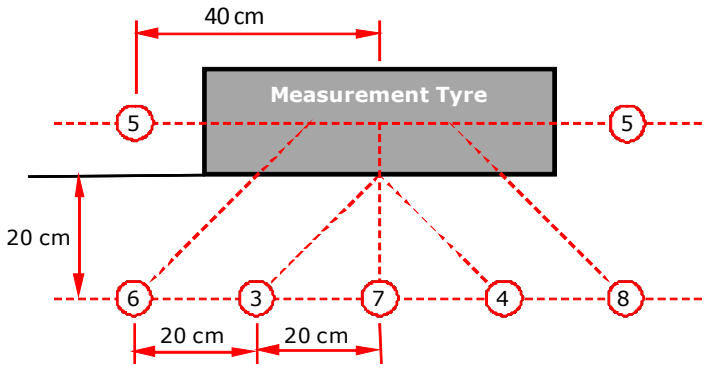
A. Phase 1 measurement programme: Preliminary selection

An extensive measurement programme has been undertaken, mainly conducted in the Netherlands by M+P for Rijkswaterstaat in a project called Robust CPX, to identify replacement reference tyres. Supplementary and extensive measurements have been made also at the

Technical University of Gdansk (TUG) in Poland. An initial list of 16 candidate tyres (8 candidates to replace ISO tyre A, and 8 candidates to replace ISO tyre D) was identified[4] and, in Phase 1 of the programme, reduced to 4 candidates for each tyre based on the correlation between CPX measurements, using the existing and new candidate tyres [5].

Measurements were taken on a range of surfaces, both dense and porous. CPX levels in the Robust CPX project were measured using a trailer (Figure 1a) with microphones at 7 positions around the test tyre (Figure 1b), including the two standard ISO microphone positions. The average noise levels were then calculated. The standard microphone positions performed well when the measured levels at these positions were compared with the average levels.

(a) The M+P CPX trailer



(b) Microphone positions for the tyre in the right-hand wheel track. Positions 1 and 2 are on the other tyre (corresponding to 3 and 4)

Figure 1: CPX trailer and microphone positions used in the study

Measurements were also made on the laboratory drum facilities of TUG. Most measurements aimed at comparing the performance of the candidate replacement tyres with the older reference tyres, tyre A and tyre D, and to determine any special features they might have.

Figure 2 shows the 4 tyres identified as candidates to replace ISO tyre A (shown in the Figure as Tyre A9). The inclusion of these tyres in the study was justified as follows:

- Tyre A3: This tyre (Vredestein Hi Trac) has a similar tread pattern to the current ISO tyre A (A9)
- Tyre A6: This tyre (Uniroyal Tigerpaw) is used in the automotive industry as a standard reference test tyre and was considered early on by WG 33 to be a potential replacement candidate
- Tyre A7: This tyre (Michelin Energy) is a very popular fuel-saving tyre
- Tyre A8: This tyre (Continental ContiEcoContact 3) is an OEM choice for many cars

Figure 3 shows the 4 tyres identified as candidates to replace ISO tyre D (shown in the Figure as tyre D9). The inclusion of these tyres in the study was justified as follows:

- Tyre D1: This tyre (BF Goodrich Mud-Terrain T/A) was considered early on by WG 33 to be a potential replacement candidate
- Tyre D4: This tyre (Avon Supervan AV4) is a relatively rough-patterned commercial tyre
- Tyres D7 and D8: These tyres (Dunlop SP LT 800 and Vredestein TransportSnow) are commercial winter tyres with rather rough-patterned treads

These tyre D replacement candidates are mainly intended for vans, large SUVs or light trucks but the smallest size is useful also on passenger cars.

Tyre A3	Tyre A6	Tyre A7	Tyre A8	Tyre A9
				
Vredestein Hi-Trac 215/65-R15	Uniroyal Tigerpaw 225/60-R16 (S.R.T.T.)	Michelin Energy 205/65-R15	Continental ContiEcoContact 3 195/65-R15	AVON ZV1 Version 2 185/65-R15 88H

Figure 2: Phase 1 candidate tyres to replace ISO Tyre A

Tyre D1	Tyre D4	Tyre D7	Tyre D8	Tyre D9
				
BF Goodrich Mud-Terrain T/A 215/75-R15	Avon Supervan AV4 195-R14C	Dunlop SP LT 800 195-R14C	Vredestein TransportSnow 195-R14C	Dunlop SP Arctic Version 2 185-R14 90Q

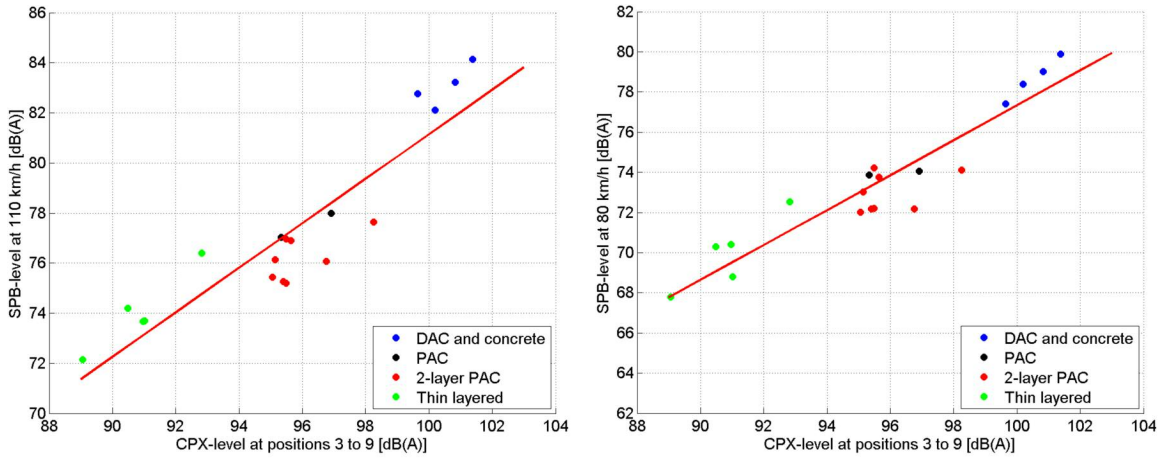
Figure 3: Phase 1 candidate tyres to replace ISO Tyre D

B. Phase 2 measurement programme: Detailed evaluation

A second phase study[6,7] has subsequently been undertaken within the Robust CPX project, which focussed on a study of the relationship between CPX levels with the 4 candidate tyres in each group and SPB levels for cars and heavy duty vehicles as appropriate for a range of speeds.

Due to space restrictions, only the results for the evaluation of candidate replacements for ISO tyre A are presented in this paper.

All of the A-candidate tyres performed well with respect to the overall representativity defined by the SPB/CPX relationship, based in measurements on a range of dense and porous surfaces. The slope for all of the candidate tyres with respect to the SPB data was close to 1. For the inner microphone positions, the standard deviation was approximately 1.2 dB for tyres A3, A7 and A8 and 0.8 dB for tyre A3. Figure 4 presents, as an example, the SPB/CPX correlations for tyre A6, using CPX measurements averaged over microphone positions 3-9.



(a) SPB at 110 km/h, CPX at 80 km/h (b) SPB at 80 km/h, CPX at 80 km/h

Figure 4: Correlation between passenger car SPB levels and average CPX levels using Tyre A6

Figure 5 presents CPX rolling noise levels for the 4 candidate tyres and the current ISO tyre A on 22 different surfaces, measured both within the Phase 2 programme and a separate study to develop a road surface acoustic optimisation tool[8].

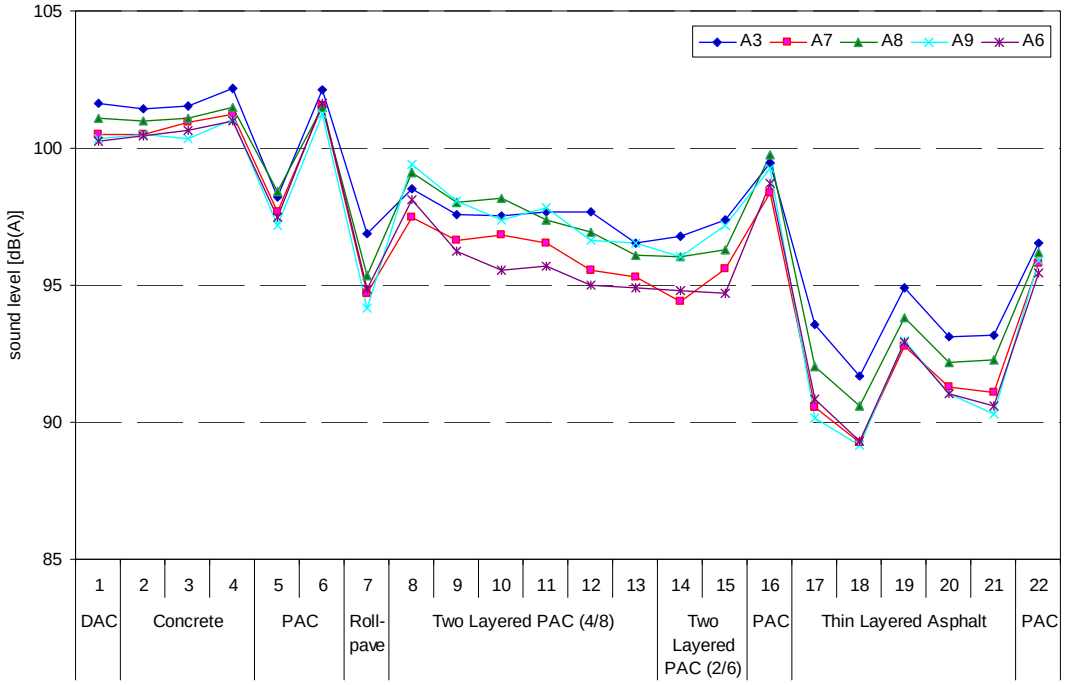


Figure 5: CPX rolling noise levels for all A-candidate tyres on different surfaces

It is observed that tyre A6 and A8 compare well with the current tyre A on single layer surfaces (both dense and porous). However, A8 compared more favourably on twin-layer porous surfaces.

An important acoustic characteristic of a road surface is the spectral performance. A good correlation between overall SPB and CPX levels does not automatically imply a good relationship between the one-third octave band spectra. Spectral representativity is defined as the scatter between the SPB spectral noise reductions and those for the corresponding CPX measurements.

The results indicated that tyre A6 exhibits a deviant spectral behaviour and had the largest standard deviation in spectral scatter of 2.6 dB. In contrast, tyre A8 gave the best representativity with a standard deviation in the spectral scatter of 1.9 dB.

Figure 6 presents the spectral comparisons between CPX and SPB measurements for tyre A6 on a range of surfaces; in each case the spectra have been normalised to 0 dB overall level.

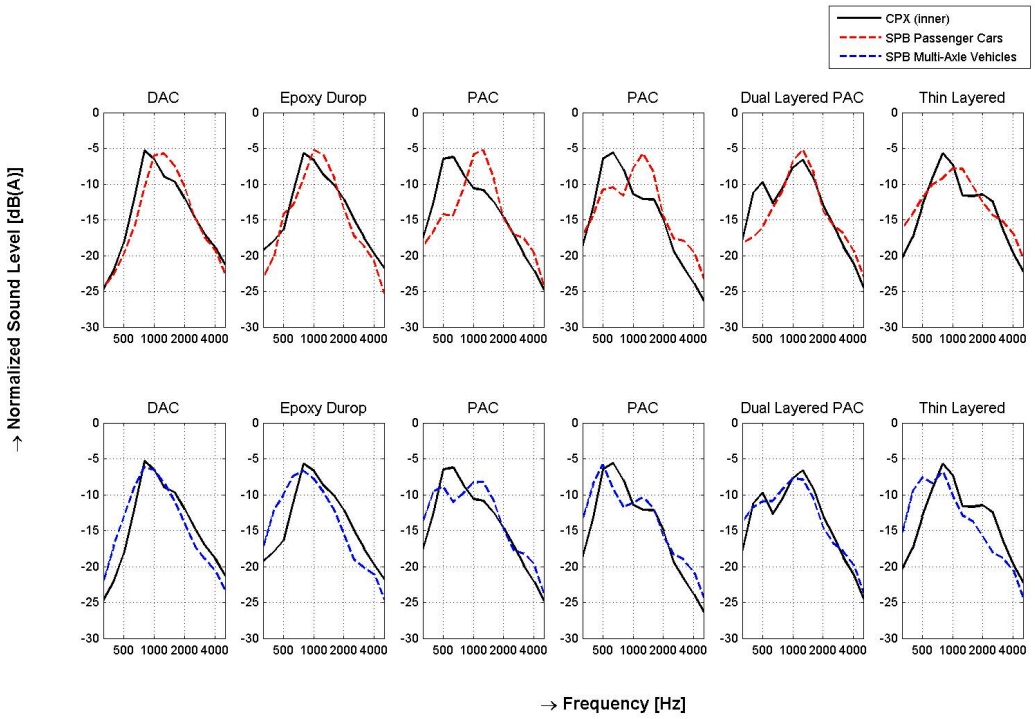


Figure 6: Comparison of SPB spectra and normalised CPX spectra measured using tyre A6 ("inner" microphone positions; i.e. 1 and 2 or 3 and 4 only)

It is noted that, based on the presented results, tyre A8 appeared to be a potentially better candidate. However, it should be noted that the Michelin Energy is not a static tyre, i.e. the design has been modified on a number of occasions. This therefore makes the tyre potentially unsuitable for use as a long-term reference tyre.

The measurements performed as part of the development of a road surface acoustic optimisation tool[8] showed that the performance of tyre A6 with respect to an average passenger car tyre (i.e. the average noise level for all of the passenger car tyres included in the study) was better at higher speeds (80 and 110 km/h). It is noted that there is better correlation with SPB results using tyre A6 than the current ISO tyre A. Tyre A7 correlated better overall with the average tyre than tyre A6. However, the same design issues apply for this tyre as tyre A8.

C. Review of results by WG 33

The results and conclusions from the measurement programme were reviewed by ISO/TC 43/SC1/WG 33, and a simple rating system applied, whereby each tyre was considered to either fulfil the criteria (perform well), demonstrate no benefit/disbenefit (be neutral) or not meet the criteria (perform poorly). The Working Group considered the long-term availability of the replacement tyres, or the potential to guarantee it, to be one of the most important factors in the final selection process, as it is this lack of availability that has resulted in the present need to select new tyres.

The results of the assessment of candidate tyres to replace the current ISO tyre A are presented in Table 1 for the tyre A assessment. The final decision was that tyre A6, the Uniroyal Tigerpaw 225/60 R16 Standard Reference Test Tyre, was chosen and subsequently voted for as the replacement for tyre A in the standard.

Table 1: WG33 Assessment of final candidate tyres to replace ISO tyre A
(+ means good, fulfilled; 0 means no info, neutral; - means bad, not fulfilled)

Property	Tyre A3 Vredestein Hi-Trac	Tyre A6 Uniroyal Tigerpaw (SRTT)	Tyre A7 Michelin Energy	Tyre A8 Continental ContiEco-Contact 3	Tyre A9 Avon ZV1 V2 (Old Tyre A)
Comparability to old tyres	+	+	+	+	+
Overall represent. for SPB	+	0	0	0	-
Spectral representativity	+	-	+	+	0
Reproducibility within batch	0	+	0	0	0
Long-term availability	0	+	0	0	0
Practicability	0	0	0	0	0
Global applicability	0	+	0	0	0
Total excluding spectral representativity	**+2**	**+4**	**+1**	**+1**	**0**
Total including spectral representativity	+3	+3	+2	+2	0

Table 2 presents the results of the initial assessment of candidate tyres to replace ISO tyre D. It is noted that identical scores were achieved by tyres D1 and D4. One further consideration in the selection of a replacement for tyre D is the outer diameter of the test tyre. In the case of two-wheeled CPX trailers, if the outer diameters are similar then it is potentially possible to perform CPX measurements with the tyre A replacement on one side of the trailer and the tyre D replacement on the opposite side. The outer diameter of the tyre A6 is 676 mm, while the outer diameters of D1 and D4 are 703 mm and 672 mm respectively. Thus, as D1 has a radius which is 13 mm greater than A6, if the tyres are put at the ends of one axle with a track width of (say) 2 m, it equals less than 0.7 %.

Based on a subsequent consideration of additional requirements for tre D, shown in Table 3, tyre D4 was voted for as the replacement for tyre D.

Table 2: Initial WG33 assessment of final candidate tyres to replace ISO tyre D
(+ means good, fulfilled; 0 means no info, neutral; - means bad, not fulfilled)

Property	Tyre D1 BF Goodrich Mud-Terrain	Tyre D4 Avon Supervan	Tyre D7 Dunlop SP LT 800	Tyre D8 Vredestein TransportSnow	Tyre D9 Dunlop SP Arctic V2 (Old tyre D)
Comparability to old tyres	+	+	+	+	+
Overall represent. for SPB	0	0	-	0	+
Spectral representativity	-	+	0	+	+
Reproducibility within batch	0	+	0	0	0
Long-term availability	0	0	0	0	0
Practicability	0	0	0	0	0
Global applicability	0	0	0	0	0
Total excluding spectral representativity	**+1**	**+2**	**0**	**+1**	**+2**
Total including spectral representativity	+1	+3	0	+2	+3

Table 3: WG33 assessment of additional requirements for candidate tyres to replace tyre D
(+ means good, fulfilled; 0 means neutral; - means bad, not fulfilled; -- means very bad, not fulfilled)

Topic of concern	Tyre D1 BF Goodrich Mud-Terrain	Tyre D4 Avon Supervan	Notes
Correlation with SRTT	+	0	Correlation should be low
Correlation with Tyre D	-	+	Correlation should be high
Side sensitivity	--	-	Which side to measure should be neutral
Load influence	0	0	Should be as low as possible
Inflation influence	+	0	Should be as low as possible
Run-in effect on noise	?	0	Should be as low as possible
Shore hardness effect on noise	?	?	Should be as low as possible

It is noted that measurements have also been carried out by other parties in addition to the studies described here which further support the final recommendations of WG 33.

The tread patterns of the chosen two replacements for tyres A and D are shown in Figures 7 and 8. Note the much larger tread blocks in the Avon AV4 than in the SRTT, which is intended to somewhat resemble differences between car and truck tyres.

Figure 7: The chosen replacement for tyre A; i.e. the ASTM SRTT tyre

Figure 8: The chosen replacement for tyre D; i.e. the Avon AV4 tyre

Based on the final selection of test tyres, i.e. tyre A6 to replace tyre A and tyre D4 to replace tyre D, the following points are noted:

- Tyre A6, the Uniroyal Tigerpaw 225/60 R16 Standard Reference Test Tyre, is not currently type-approved. This may be an issue when performing CPX measurements with the test tyre mounted on a vehicle rather than a trailer and is to be investigated
- It is not proposed that there will be any changes in tyre load in the revised ISO standard due to the introduction of the new reference tyres. An increase in inflation pressure to 200 kPa ± 10 kPa will be introduced. Limit values for acceptable tyre hardness are to be prepared and will be included in the Technical Specification on the tyres, together with advice on how to preserve the original hardness for as long as possible
- With regard to the long-term availability of the Avon AV4 (D4), it is expected that either some agreement will be reached with Avon Cooper Tires on their availability or a large set of tyres will be purchased stored in the best possible way for a very long time

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