Long-Term Changes in Road Surface Noise Measured by the CPX Method,

National Specification 270

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Abstract

Road traffic noise is significantly influenced by road surface properties, in particular by the surface type and its condition. The noise generated at the tyre–road interface is commonly assessed using the Close Proximity (CPX) method according to ISO 11819-2 [1], which enables direct source related measurements.

This contribution addresses long term monitoring of the noise emission of different road surface types in the Czech Republic, with a strong international relevance. At the national level, a new road surface noise classification system (TP 270) is being introduced in connection with the implementation of the CNOSSOS-EU calculation methodology for road surface noise. The system enables:

- detailed assessment of the acoustic condition of road surfaces,
- tracking of acoustic degradation over time,
- and optimization of road design and maintenance aimed at reducing traffic noise exposure.

Long term results confirm consistency with international datasets, providing a reliable basis for the assessment and prediction of road surface noise within the EU.

Keywords: *tyre-road noise, CPX method, road pavement, noise classification*

1. Introduction

Road traffic noise has a significant impact on health [2] and quality of life, especially in urban and residential areas where road traffic is the dominant noise source.

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Tyre–road interaction noise becomes the decisive component of overall traffic noise approximately above 40 km/h for vehicles with internal combustion engines and above 20 km/h for electric vehicles [3].
The acoustic performance of road surfaces is commonly assessed using the CPX method, an internationally recognized standard technique that measures noise close to the source using a reference tyre and microphones located in the immediate vicinity. CPX outputs can be used for:
assessment of low-noise and conventional surfaces,
development of classification scales,
monitoring surface degradation over time,
and implementation in CNOSSOS-EU calculation models [4] for strategic noise mapping.
This paper focuses on the use of long term CPX monitoring results for different surface types, the determination of reference noise values and a classification system for low-noise and conventional pavements, linking measured data to CNOSSOS-EU, and tracking long-term changes in the acoustic performance of road surfaces and their use within international technical specifications.

2. Long-term noise measurement using the CPX method

All measurements were performed using the Close Proximity (CPX) method according to ISO 11819-2, a standardized dynamic approach for assessing noise generated at the tyre–road interface. The principle is based on placing microphones in the immediate vicinity of the reference tyre, enabling source related sound pressure measurements while minimizing the influence of the surrounding environment.
The method is based on the reference tyre Uniroyal Tigerpaw 225/60 R16 SRTT, recommended by ISO/TS 11819-3 [5] and used in the automotive industry according to ASTM F2493. An open measurement trailer is used; up to six microphones are installed around the reference tyre at precisely defined positions, with at least two microphones being

mandatory and the remaining four optional (see Figure 1).
In the European Union, CPX is a standard tool for assessing road surface acoustic properties. Its outputs are applicable within the CNOSSOS-EU calculation framework and for strategic noise mapping in accordance with Directive 2002/49/EC on the assessment and management of environmental noise.

Figure 1. Open CPX trailer used for measurements (designed by CDV).

Long-term noise measurements and the systematic collection of acoustic road surface data provide key input for performance evaluation and for the design of effective traffic noise mitigation measures. These data contributed significantly to the development of the national specification TP 270, to updates within TKP 7, and were also used in the preparation of the international technical specification CEN/TS 18194 “Road and airfield surface characteristics - Characterisation of the acoustic properties of road surfaces” [6], which, among other objectives, aims to introduce a comparable reference surface.
Continuous acquisition of long-term series enables not only monitoring of degradation processes, but also optimization of road design and maintenance in terms of acoustic efficiency.
Long-term noise evolution can best be tracked by regular (typically annual) measurements conducted since 2012 within various research projects. This allows the analysis of temporal trends for specific surface types, for example SMA 11 surface and noise reducing concrete surfaces (cement concrete treated by burlap drag (CCBD)) on the D1 motorway. The combined dataset from 2012–2024 provides a representative picture of noise changes over the pavement lifetime (see Figure 2). The results focusing on long-term noise measurements of the comparison of exposed aggregate cement concrete surfaces and stone mastic asphalt are presented in the contribution [7].

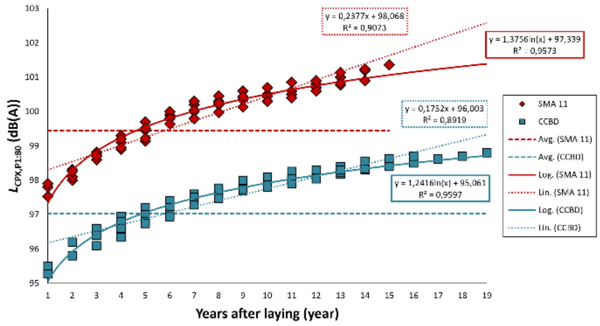

Figure 2. Long-term noise development of a conventional (SMA 11) and noise-reducing CCBD on the D1 motorway, measurements were carried out 2012–2024 [8].

Optimizing road surface properties based on these findings can significantly reduce population noise exposure. According to the World Health Organization, traffic noise is one of the most important environmental risk factors affecting human health, with substantial health, social and economic impacts. Therefore, traffic noise management remains a priority in the context of Directive 2002/49/EC and the associated CNOSSOS-EU methodology.

3. Average noise reduction values for different surface types

In the analysis of CPX measurements in the Czech Republic—also used to develop the classification scale—the same dataset was used to determine average noise changes relative to the defined reference value. The analysis covered thousands of unique measurements across pavements of different types and ages, including repeated measurements from regular annual monitoring. This extensive database enabled the calibration and verification of acoustic properties for the most common surface types in the Czech Republic and their subsequent implementation in CNOSSOS-EU.
At the national level, an overview of the most frequently used road surfaces on the Czech road network was prepared with a focus on noise emission, defining 10 surface groups for classification and modelling purposes. These groups were implemented in CNOSSOS-EU.
The surface groups are defined as follows:

1. Cobblestones (CS)
2. Low-noise asphalt pavements (LN1)
3. Noise-reducing asphalt pavements (LN2)
4. Cement concrete treated by burlap drag (CCBD)
5. Exposed aggregate cement concrete (EACC)
6. Dense asphalt concrete with the highest grain size 11 mm (DAC 11)
7. Stone mastic asphalt with the highest grain size 11 mm (SMA 11)
8. Fine-grained asphalt mixtures with the highest grain size 8 mm (FGAM)
9. Coarse-grained asphalt mixtures with the lowest grain size 16 mm (CGAM)
10. Slurry seal / micro surfacing (SSMS)

Table 1 (classification of surface types) presents the national CPX-based classification. This structure can be applied consistently with CNOSSOS-EU for national-level acoustic calculations, as it allows assignment of appropriate acoustic characteristics to each surface group. The defined groups therefore provide a practical basis for a harmonized approach to road surface noise evaluation within traffic noise models. CNOSSOS-EU is currently being considered as a recommended national approach for acoustic calculations.
The values in Table 1 were obtained from a statistical evaluation of real CPX measurements in the Czech Republic in accordance with ISO 11819-2. Values may vary at a specific site depending on:

- construction quality,
- meteorological conditions,
- traffic conditions (speed, flow, fleet composition),
- and the condition of the road (potholes, ruts, surface distress, etc.).

Interpretation of table values (Table 1):

- positive value: the surface is noisier than the reference value,
- negative value: the surface is quieter than the reference surface,
- “X”: long-term data are not available in the Czech Republic, or the dataset is not statistically robust (e.g., new technologies, or surfaces with very long service life, such as certain concrete pavements).

Table 1. Average noise change values in dB(A) for different surface types relative to the reference value of 98 dB(A) for speed 80 km/h.

Surface	Acoustic group	0 year	2 years	5 years	10 years
Cobblestones	1	+7.0	+7.0	+7.5	+8.0
SMA 8 LN	2	-5.0	-3.0	-1.0	X
BBTM 8 LN	2	-4.0	-3.0	-1.5	X
BBTM 8 A	3	-2.0	-1.0	0.0	X
CCBD	4	-2.0	-1.5	-0.5	0.0
EACC	5	-0.5	+0.5	+1.0	+2.0
DAC 11	6	-1.0	-0.5	+0.5	+2.0
SMA 11	7	-0.5	+0.5	+1.5	+2.5
SMA 8	8	-1.0	-0.5	+0.5	+1.5
DAC 16	9	0.0	+1.0	+1.0	+2.0
SMA 16	9	+0.5	+1.5	+2.0	X
Slurry Seal	10	+1.0	+0.5	+1.5	X

The acoustic group (see Table 1) corresponds to the 10 surface groups mentioned above. The table presents a proposed update of the TKP 7 (proposal for TP 270), which was used in contribution [9]. The table from TKP 7 was used based on 5-year-old data. Information in this capture is included in TP 270.

4. Evaluation and classification of pavement noise

The classification of road surface noise using the CPX method is based on a comparison of the measured value with a defined reference value. The reference value represents the typical noise emission of a conventional reference surface and serves as a normalization basis.
This classification may be used solely for measurements performed using the CPX method in accordance with ISO 11819-2 and only when using the P1 reference tyre in accordance with ISO/TS 11819-3. An article [8] was devoted to this issue.
Reference values were established based on an extensive database of measurements in the Czech Republic and represent typical noise levels of conventional asphalt mixes at 1–2 years of age. The reference values are:

- 98.0 dB(A) at the reference speed of 80 km/h,
- 90.0 dB(A) at the reference speed of 50 km/h.

A reference acoustic value is defined for the evaluation, against which the measured values are compared. The reference noise levels correspond to the average actual noise levels of conventional surfaces (e.g., SMA 11, DAC 11, EACC) that are 1–2 years old.
Two separate national classification scales are defined:

1. for low-noise surfaces,
2. for other (conventional) road surfaces.

Both scales comprise five classes representing progressive acoustic degradation over the surface lifetime (service life).

4.1 Classification scale for low-noise (LN) pavements

For low-noise surfaces, classification is stricter than for conventional ones because the primary objective is to reduce traffic noise in noise-sensitive locations. To be labelled as a low-noise surface, the surface must provide at least a 2 dB(A) reduction compared to the reference value after laying.
The five-class scale for low-noise pavements can be interpreted as:

- **Class 1**: the surface meets the requirements for a new LN pavement one year after laying.
- **Classes 2–4**: gradual degradation of LN pavements (extending the former pass/fail approach and enabling road authorities to track performance development).
  - **Class 2**: typically reached 2–4 years after laying.
  - **Class 3**: typically reached 3–6 years after laying.
  - **Class 4**: typically reached 5–9 years after laying; threshold where the surface still meets LN requirements.
- **Class 5**: the surface no longer meets LN requirements.

The typical asphalt mixture such as SMA 11 or DAC 11, being the most common surfaces in the Czech Republic, shows a noise increase of about 1 dB(A) two years after laying.
After 10 years in service, this increase reaches approximately 3–4 dB(A) from the initial value, provided the surface has no significant defects (potholes, rutting, wheel tracks, extensive transverse or longitudinal cracks). In the case of severe defects, the noise level on that type of surface may be up to an additional +6 dB(A) higher than the values listed in the table (see Table 1).

Table 2 provides the classification scale for low noise surfaces at 80 km/h (a corresponding scale is available for 50 km/h). The most important classes are Class 1 (required after laying to declare a low-noise) and Class 5 (surface can no longer be considered low-noise).

Table 2. Classification scale for low-noise pavements – value ranges dB(A) for the reference speed of 80 km/h.

1	2	3	4	5
≤ 96.0	96.1 – 97.0	97.1 – 98.0	98.1 – 99.0	≥ 99.1

4.2 Classification scale for other surfaces

The second classification scale applies to conventional surfaces, such as standard asphalt surfaces (e.g., SMA 11, DAC 11), thin-layer treatments and continuous maintenance technologies (e.g., micro surfacing, coating), mastic asphalt, cement concrete surfaces (e.g., exposed aggregate technology), layers using more dense fine-grained mixtures (e.g., BBTM 8, SMA 8), layers with coarse-grained mixtures (e.g., DAC 16, SMA 16), paving blocks (e.g., interlocking blocks, cobblestones), and others.
Paved block/cobblestone surfaces typically fall into the highest class (Class 5) immediately after construction (better fit than laying) due to their high initial noise emission.
The five-class scale for conventional surfaces can be interpreted as:

- **Class 1**: new conventional surface.
- **Class 2**: conventional surface approximately 1–2 years old (national reference 98.0 dB(A), defined as the mean of SMA 11 and DAC 11 values at 1–2 years based on Czech measurements).
- **Class 3**: conventional surface without major defects, approximately 5 years old (international reference 99.1 dB(A) reported in CEN/TS 18194, defined as the average of SMA 11 and DAC 11 values at 2–7 years across an EU survey).
- **Class 4**: conventional surface without major defects, approximately 10 years old.
- **Class 5**: conventional surface at the end of its acoustic lifetime; surface with significant defects.

Table 3 presents the classification scale for other surfaces at reference speeds of 80 km/h. The scale enables monitoring of acoustic ageing, comparing different surface types, and identifying surfaces with high noise levels.

Table 3. Classification scale for other (conventional) surfaces – value ranges dB(A) for the reference speed of 80 km/h.

1	2	3	4	5
≤ 98.0	98.1 – 99.0	99.1 – 100.0	100.1 – 101.0	≥ 101.1

The international reference value of 99.1 dB(A) (CEN/TS 18194), corresponding to the average noise emission of SMA 11 and DAC 11 surfaces aged 2–7 years within the EU, was also confirmed by national data (for an age of approximately 5 years). Information in this capture is included in TP 270.

5. Discussion and conclusion

Long-term results confirm that the CPX method is a robust and reproducible tool for assessing road surface noise emission. Its key advantage is the capability of continuous measurements over long road sections while minimizing the influence of the surrounding environment, thereby providing representative data on noise generated directly at the tyre–road interface.
Long-term monitoring data collected since 2012 within CDV activities enabled:

- the establishment of reference noise values,
- the development of a unified five class classification system replacing the former simplified pass/fail approach and providing more detailed information on surface acoustic condition,
- monitoring of progressive acoustic degradation and identification of surfaces close to the end of their acoustic lifetime.

The continuously collected data have been used for:

- national specification TKP 7 (implemented),
- national implementation of CNOSSOS-EU (implemented),
- CEN/TS 18194 (implemented),
- TP 270 (approval process ongoing),
- revision of ISO 11819-2 (initiated).

The statistical analysis of thousands of unique CPX measurements across pavements of different types and ages was used not only to develop the classification scale, but also to determine average noise changes relative to the reference value. The dataset enabled verification of acoustic properties of the most common road surfaces in the Czech Republic, their implementation in CNOSSOS-EU (considered as a recommended national calculation methodology), and their use within CEN/TS 18194. Long-term monitoring improves the accuracy of traffic noise models and supports more effective design of mitigation measures. With the increasing share of electric vehicles, powertrain noise will become less dominant and tyre–road noise will gain further importance, underlining the need for systematic monitoring. This topic is also being addressed at the international level [10].

In conclusion, CPX monitoring combined with a unified classification system represents an effective tool for traffic noise management, optimization of road design and maintenance, improved noise mapping, and targeted reduction of adverse impacts of transport on the environment and public health.

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