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RAILWAY NOISE AND ITS LIMIT VALUES

Summary. The noise pollutes the environment. The paper deals with comparison of noise limit values in several countries of Europe and in the world, calculation of equivalent noise level, measurements of different equivalent sound pressure levels in the railways and their frequency spectra for specific railway track and comparison of the limit value for Slovak Republic with the calculated value.

HAŁAS KOLEJOWY I JEGO WARTOŚCI GRANICZNE

Streszczenie. Hałas negatywnie oddziałuje na środowisko przyrodnicze. Artykuł prezentuje: analizę porównawczą granicznych poziomów w wybranych krajach europejskich i na świecie, zasady obliczania ekwiwalentnego poziomu hałasu pochodzącego od ruchu kolejowego, pomiar różnych wartości poziomów ciśnienia akustycznego i ich widma częstotliwości na konkretnej linii oraz porównanie dopuszczalnego w Słowacji poziomu z obliczoną wartością.

1. INTRODUCTION

In many industrialised countries, noise has developed into a severe environmental problem. The most of citizens are daily annoyed by excess noise not only in offices and outside but also at home and at the rest time. According to a surveys, cca 60 % from overall noise is generated by noise from work environment and 75% - 85 % from that is transportation noise [1]. The important quantities are not only maximum and minimum value of the noise but also the duration, its character and frequency spectrum. The L_{pAeq} (energy equivalent sound pressure level) is the energy averaged sound level over a given period of time with filter A (dB), which considers the sensitivity of the human ear.

Transportation noise has the greatest part on noise pollution of the environment. The comparison of noise level caused by each type of transportation [5]:

air transport	10 %
railway transport	14 %
road transport	76 %

2. REGULATIONS ON THE NOISE

Noise pollution is an increasing problem not only within the European states but it is a whole world problem. The European Commission has in recent years intensified activities

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within noise abatement. Examples of the results of the Commission activities can be illustrated by preparation of the Green book on Noise Policy. [2]

The Organisation of Economic Cooperation and Development (OECD) edited a report, in which allocated the noise immision in highly impacted areas - "black spots" (exposed to levels of more than 65 dB in the daytime) which member has been stabilised, while the member of medium exposure to noise - "grey areas" (55 – 65 dB) is increased. This development is primarily due to the rapidly increasing volume of traffic. The situation in the EU is that about 20 % of the population lives in black spots, and about 40 % lives in grey areas along roads. The values for railways are 2 % and 8 % respectively. [6]

Increasing exposure and increasing public awareness have meant that noise regulations have been reviewed or updated to comply with the requirements of modern noise abatement policies.

3. THE RAILWAY NOISE LEGISLATION PARAMETERS

For the railways, most countries have legislation on the noise imission level caused by the railway traffic (total contribution from vehicle and track), and few countries have legislation on rail vehicle noise emission level as well. The most of the EU countries have noise reception limits from railways, when concerning new lines and upgraded lines. But only few countries have noise reception limits for existing railways.

As the legislation parameters among countries varied, only approximate comparison can be made. The important parameters are:

- reference period – most countries operate with two reference periods – noise limits for day (from 6,00 to 22,00 hod) and night period (from 22,00 to 6,00 hod). The times dividing the day and night periods are slightly different. The typical day period is from 6 in the morning until 22 in the evening. Sweden, Norway and Denmark use a 24 hours value, and The Netherlands uses three periods: day – evening – night. The new high – speed line in Belgium (Walloon region) has four periods: morning – day – evening – night.[4]
- Receiver position – in most of the countries the noise reception level is defined as a free field value. In some cases the value is defined on the facade or in 1 or 2 meters distance of the facade, which will result in a 3 – 6 dB correction of the measured noise level.
- Noise parameter definition – all countries are using the energy equivalent sound pressure level L_{pAeq} [dB]. The rail bonus is used when the regulation is valid for both road and rail traffic. It can have values between 3 and 15 dB. The rail bonus is introduced due to less annoyance from rail bound noise compared to noise from road traffic. Some countries also use maximum sound pressure levels (L_{pAmax}). [2]

The Fig. 1 presents the noise limit values from different countries for new and upgraded railway lines.

In almost all countries the same limits are valid for both high – speed trains and conventional trains. Although Germany, United Kingdom, Belgium, Sweden and the Netherlands have high speed train operation, only France and Italy have special noise limits covering high-speed trains. Belgium has guidelines for one high – speed line. High speed is in France defined as speed above 250 km/h and in Italy as speed above 200 km/h.

It can be seen that the maximum permissible noise levels are in the range 55 – 73 dB for the day period and 45 – 70 dB for the night period. Noise limits for existing lines are the same in many cases or about 5 dB to 10 dB higher than for new and upgraded lines.

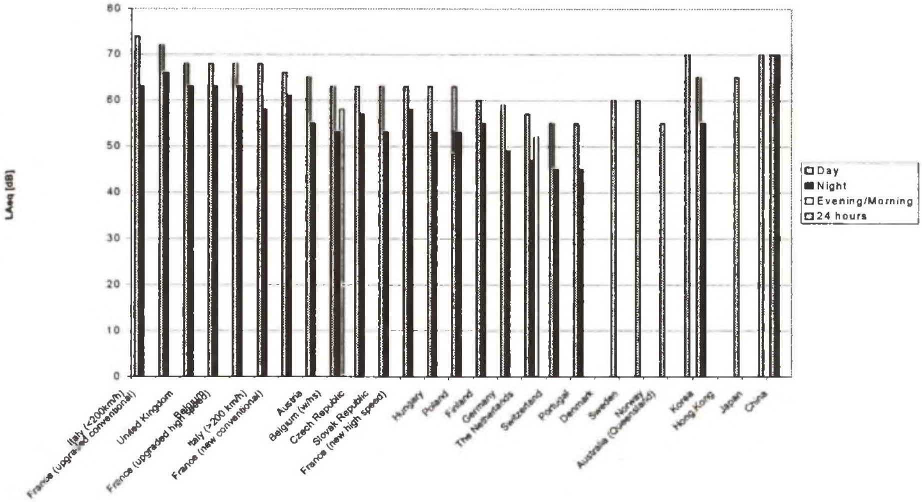

Fig. 1. Exterior Residential Noise Limits (L_{Acq}) for New and Upgraded Railway Lines

Rys. 1. Zewnętrzne graniczne poziomy hałasu w strefie mieszkaniowej (L_{Acq}) dla nowych i modernizowanych linii kolejowych

4. NOISE PREDICTION MODELS

There are many calculation models for the prediction of noise level along railway lines. For example: Dutch calculation model, Nordic Prediction Method, Richtlinie zur Berechnung der Schallimmissionen von Schienenwegen, Lärmschutz – Verordnung (LSV), UK Calculations of Railway Noise simulation models such as the Swiss SEMIBEL or the French MITHRAFER and others. The prediction methods around Europe differ in many ways. Furthermore, within the same prediction method there are many factors that cause uncertainties. How conservative or liberal these corrections are, it determines a major uncertainty of the predicted noise level when comparing to a measured noise level. [3]

Standardised prediction procedures are not in force in Slovak Republic. The calculations are made according to the directive "Metodické pokyny pro výpočet hladin hluku z dopravy". The traffic parameters are put into the calculation.

The formulas [7] used in calculation are:

$$Y = 10 \cdot \log X + 40 \tag{1}$$

where

$$X = 140 \cdot F4 \cdot F5 \cdot F6 \cdot m \tag{2}$$

where

m – number of passing trains per hour

F4 – traction correction (1,00 – for the diesel traction, 0,65 – for the electric traction),

F5 – speed correction, km/h

$$F5 = 0{,}241 \cdot e^{(0{,}024v)} \tag{3}$$

F6 – correction of average number of vehicles "z" (carriages and locomotives) per train

$$F6 = 0{,}0375 \cdot z + 0{,}5 \tag{4}$$

These formulas are used for calculation of the equivalent sound pressure level in the straight railway line where other noise is not predicted. There are more corrections for calculation for the additional noise (from passing over switches, from interlocking plant, from passing through the bridges, and so on).

5. EXPERIMENTAL MEASUREMENTS

Experimental measurements were realised during standard traffic situation in workday in the Žilina – Čadca railway line (km 253,1) where the railway track passes over Brodno village and there is a plan to built an acoustic shielding in the future. The railway track will be a part of the trans European corridor No. VI, that will connect Hungary with Poland through the Slovak Republic.

Measuring microphone (Brüel & Kjær type, 4188) was situated 7,5 m from the axle of the track and was 1,5 m under the surface of rail because the railway track is on embankment. Due to the train pass on the first rail or second rail the distance of the source of the noise from the microphone was cca 7,5 m (rail No.1), or 12,5 m (rail No.2).

Character of equivalent noise pressure levels from the passenger and cargo train is illustrated on Fig. 2, 3, 4, 5. Dashed and dotted lines are for the maximum equivalent sound pressure level and the full dash is for equivalent sound pressure level (A). [8]

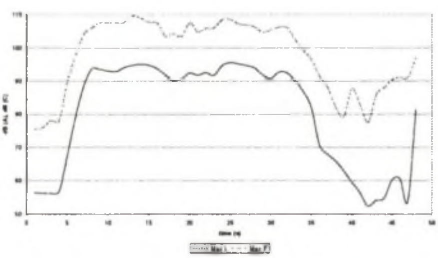

Fig. 2. Passage of the freight train

Rys. 2. Przejazd pociągu towarowego

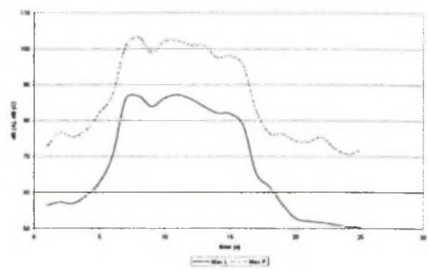

Fig. 3. Passage of the passenger train No. 3909

Rys. 3. Przejazd pociągu pasażerskiego No. 3909

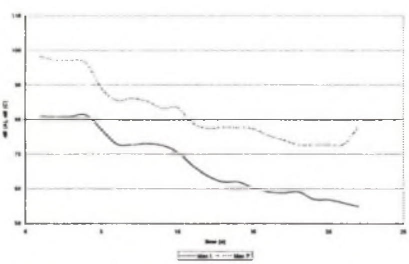

Fig. 4. Passage of the passenger train No. 3910

Rys. 4. Przejazd pociągu pasażerskiego No. 3910

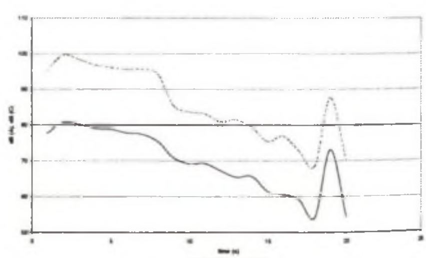

Fig. 5. Passage of the express train No. 140 – Detvan

Rys. 5. Przejazd pociągu ekspresowego No. 140 – Detvan

The values of the maximum and minimum equivalent sound pressure level are presented in the Tab.1.

Table 1

Values of the maximum and minimum measured equivalent sound pressure levels

	rail	Speed [km/h]	MaxP [dB]	MaxL [dB]	MinL [dB]	L5 [dB]	L95 [dB]
Freight train	1	80	109,6	95,6	47,8	94,5	51
Passanger train No. 3910	2	100	98,2	81,5	54,4	80,5	55,5
Expres Detvan	2	100	99,6	80,8	49,3	78,5	52,5
Passanger train No. 3909	1	100	103,2	87,2	46,6	85,5	48,5

MaxP - maximum reached pick of noise level in dB (C) in the period of measure,
MaxL - maximum reached pick of noise level in dB (A) in the period of measure ,
MinL - minimum reached pick of noise level in dB (A) in the period of measure,
L5 - statistic noise level – in 5 % of the measured time was the noise level higher than found value in dB (A),
L95 - statistic noise level – in 95 % of the measured time was the noise level higher than found value in dB (A) (this level is practically the noise level of the background).

The distance of the measuring apparatus from the source of the noise (passing the train in the 1^{st} or 2^{nd} rail), the velocity, type and composition of the train have influence on the course and maximum values of the record. From the graphs and values, it can be seen that the freight train emitted about 6,4 dB (6,2 %) more noise at MaxP and 8,4 dB (9,6 %) more at MaxL [dB(A)] than the passenger train.

Parameter L95 expresses the noise level of the background, which is caused by passing of the cars on the road.

- Frequency analysis of the railway noise

Each train passages were examined also from the point of the view of frequency analysis. The passing trains generated noise with wide frequency spectrum (Fig. 6) in which the highest values were reached at the low frequency noise (Fig. 7) [8].

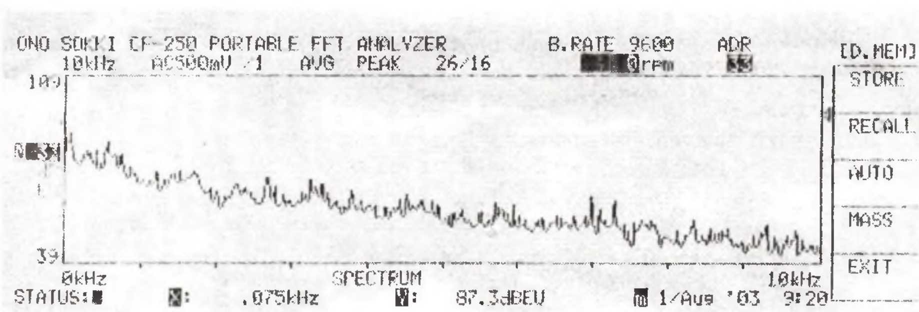

Fig. 6. Record of the frequency spectrum of the noise from the passenger train No. 3909 passing in the Žilina – Čadca railway line

Rys. 6. Zapis widma częstotliwości hałasu dla pociągu pasażerskiego No. 3909 (Žilina – Čadca)

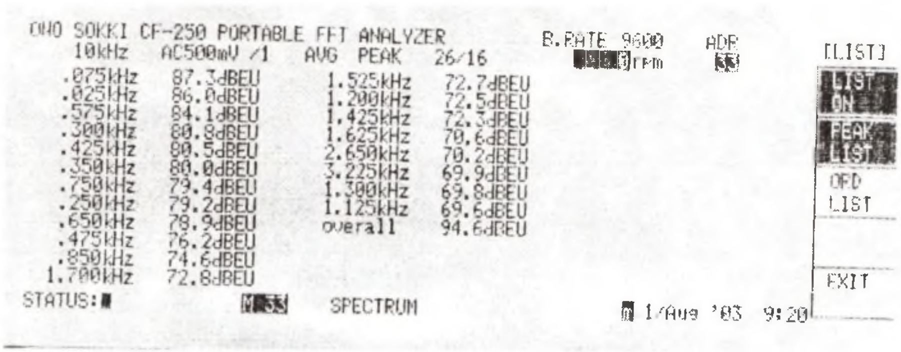

Fig. 7. Numerical values of the noise frequency spectrum at the first highest amplitude of the noise

Rys. 7. Wartości numeryczne widma częstotliwości szumów dla pierwszej najwyższej amplitudy hałasu

In the Fig. 7 the twenty highest values of the energy equivalent sound pressure level L_{pAeq} and theirs equivalent frequency can be seen.

The two highest values of noise pressure level are:

87,3 dB – 75 kHz

86,0 dB – 25 kHz

The measured values confirm that the highest value of the noise is caused by the rolling of the wheel in the rail. That action generates noise with very low frequency.

The noise with the same intensity is perceived according to its frequency. The noise with low frequency is perceived less noisy than noise with high frequency. Therefore people are less annoyed by railway transport, because the low frequencies here are more dominated than in the noise from the road and air transport.

6. CALCULATED NOISE PRESSURE LEVEL L_{PAEQ}

The energy equivalent sound pressure level L_{pAeq} was calculated for the railway line Žilina – Čadca. The prediction model for Slovak Republic was described above.

Determined traffic parameters were founded out at April 2004:

m = 4,26 trains/hour (number of passing trains per hour),

F4 = 0,65 (traction correction),

Using the formula (3):

F5 = 2,66 for v=100 km/h (speed correction)

Using the formula (4):

F6 = 1,18 for z = 18,25 (correction of average number of vehicles “z” per train)

Than using the formula (2)

X= 1216,79

and using formula (1)

Y = 70,9 dB

This equivalent sound pressure level is calculated for straight railway track with no others corrections. Comparing this value with the limit value (63 dB) it is apparent that the calculated noise value exceeds by about 7,9 dB (12,5 %) the limit value.

Considering that the railway track passes over the Brodno village, the citizens are annoyed by the railway noise and construction of the acoustic shielding will be beneficial for the environment in the future.

7. CONCLUSIONS

Comparing the legislative rules in all the countries covered is a rather complex task, as number of details must be evaluated. Each country has a different noise indicators and parameters so the railway noise limits are difficult to compare. Slovak Republic released the Government Regulation No. 40/2002, valid from 16.01.2002, in which the highest allowable energy equivalent sound pressure levels from traffic over daytime and night – time depend on the different areas (more or less sensitive) are given. But there are no specific regulations with regards to railway noise perception.

For the railway track Žilina – Čadca the equivalent sound pressure level reached the values from 80 to 95 dB(A) from the passing train. The freight train emitted about 8,4 dB (9,6 %) more noise (sound pressure level with filter A) than the passenger train.

The highest values of the noise have the low frequency with 25 and 75 kHz that confirm that the highest value of the noise is caused by the rolling of the wheel in the rail.

The calculated noise value for this railway track is 70,9 dB that overpasses the limit value by about 7,9 dB (12,5 %) and annoyed the citizens living near the railway track.

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Abstract

Noise pollution from the transport is an increasing problem. Noise measurements serve for the analysis and monitoring of the emission values depend on passing of various types of trains. The measuring and evaluation of the railway noise levels is very important for abatement the noise with new construction of the railway or its parts, or designing the acoustic shielding, or for design a new railway legislation for noise limits in the new, upgraded and existing railway lines.