TESTING THE ACOUSTIC ENVIRONMENT OF THE ROAD-RAIL VEHICLE IN NORMAL OPERATION CONDITIONS – ANALYSIS OF REGULATIONS

Abstract

This article refers to the problem of measurement of general and local vibration and noise generated during operation of the road-rail vehicle. It describes the documents connected with measurement of vibroacoustic factors inside the road-rail vehicle during its running and standstill and their influence on human body.

INTRODUCTION

Road-rail vehicles are the vehicles that can move both on railway tracks and roads [1]. Their design is based on road vehicles such as farm tractors, off-road vehicles and trucks. Because of their many advantages including [1]:

- low construction cost in comparison with typical railway vehicles,
- low operating, maintenance and repair costs are mainly linked with low consumption of diesel oil and lubricants,
- high availability and full use in works carried out on rail tracks and roads,
- possibility of parking in a garage typical for road vehicles or under umbrella roof,
- possibility of getting to worksites located on a track by using motor roads,
- high reliability and safety in works carried out on a track and road,

they are increasingly and more willingly used in transport depots and shunting yards, steelworks and also shipyards to carry out specialized works and light shunting works.

To be able to move on railway tracks, the road vehicles have been redesigned and equipped with additional systems such as rail wheel system or pull and bumper system. Although the bases of those vehicles meet guidelines for operator exposure to vibration and noise, the road-rail vehicles constructed from them have not been subject to such type of tests. It is known that the additional systems and equipment installed in those vehicles may be a source of vibration and noise having negative impact on the operator work.

Excessive vibration and noise are undesirable and harmful phenomena not only as creating interference in correct operation of the machine (vehicle), but also as being harmful to a human being (operator). The phenomena such as general and local vibration and noise are reasons for many ailments that may directly affect safety and develop into diseases after certain time that may even lead to death.
1. STANDARDS AND REGULATIONS CONNECTED WITH EVALUATION OF VIBRATION AND NOISE IN ROAD-RAIL VEHICLES

Currently applied standards and regulations do not directly refer to the road-rail vehicles as regards their use for measurements and evaluation of exposure to human body. Therefore, for measurements and evaluation of adverse effects of operator exposure to vibration and noise in the road-rail vehicle, one should make use of general standards and regulations and the ones referring to railway and road vehicles.

1.1. Vibration

The first document referring to vibration as harmful factor to a human being is Directive 2002/44/EC [2] of the European Parliament and of the Council of 25 June 2002 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration) (sixteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC). The directive establishes the minimum health and safety requirements arising or likely to arise from exposure to mechanical vibration. It includes, among other things, classification and definitions of vibration, exposure limit values and action values as follows:

For hand-arm vibration:
- the daily exposure limit value standardised to an eight-hour reference period – 5 m/s²,
- the daily exposure action value standardised to an eight-hour reference period – 2.5 m/s².

For whole-body vibration:
- the daily exposure limit value standardised to an eight-hour reference period – 1.15 m/s²,
- the daily exposure action value standardised to an eight-hour reference period – 0.5 m/s².

The directive also includes general requirements regarding evaluation and measurements of vibration and indicates the standards specifying the detailed requirements. Moreover, it determines employers’ obligations related to protection of employees against risk arising or likely to arise from exposure to mechanical vibration during work.

As a result of implementing the directive 2002/44/EC by Poland, the Regulation of the Minister of Economy and Labour of 5 August 2005 [14] on safety at work for works connected with exposure to noise or mechanical vibration was implemented. The regulation introduces an additional evaluation criterion of the daily exposure limit to vibration – exposure action value that amounts to:
- hand-arm vibration (local vibration) – $A(8)_{\text{action}}=2.5$ m/s²,
- general action vibration (general vibration) $A(8)_{\text{action}}=0.5$ m/s².

If the exposure action values are exceeded, the regulation obliges an employer to take action to reduce occupational risk. General principles on taking measurements of mechanical vibration in the workplace are defined by:

Regulation of the Minister of Health of 20 April 2005 [15] on the tests and measurements of agents harmful to the health in the workplace. The regulation regulates the procedure, methods, type and frequency of tests and measurements of agents harmful to health in the workplace. If the action thresholds are once exceeded, the regulation obliges the employer to take action to reduce occupational risk.

However, the detailed methods for taking the measurements of vibration are defined by Polish standards:

a) PN-EN ISO 5349-1 [7]. This part of the standard provides general requirements for measuring hand-transmitted vibration exposure and reporting the results obtained. It includes terms, definitions and symbols. It presents the characteristics of mechanical vibration transmitted into the hands and characteristics of hand-transmitted vibration exposure. It is applicable to periodic and to random or non-periodic vibration.
b) PN-EN ISO 5349-2 [8]. The standard provides guidelines for the measurement and evaluation of hand-transmitted vibration at the workplace. It describes the precautions to be taken to make representative vibration measurements and to determine the daily exposure time and also to calculate the vibration total value. It applies to all situations where people are exposed to vibration transmitted to the hand-arm system by hand-held or hand-guided machinery, vibrating workpieces, or controls of mobile or fixed machinery.

c) PN-EN 14253 [6]. This standard provides guidelines for the measurement and evaluation of whole-body vibration at the workplace. It describes the precautions to be taken to make vibration measurements, terms and definitions, values determined and preparation of the measurement procedure. It applies to all situations where people are exposed to whole-body vibration at the workplace.

d) PN-91/N-01352 [4]. The standard includes the principles on taking measurements of mechanical vibration at the workplace when influence of vibration on human body is evaluated. It is used for taking measurements of vibration acceleration affecting in a general and/or hand-transmitted way on human body to evaluate risk.

1.2. Noise

The analysis of standards and regulations regarding evaluation of noise level in means of transport for its adverse effect on human health showed existence of the following documents: Directive 2003/10/EC [3] of the European Parliament and of the Council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise) (seventeenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC). The directive establishes minimum requirements for the protection of workers from risks to their health and safety arising or likely to arise from exposure to noise and in particular the risk to hearing. It defines the physical parameters that serve as noise risk predictors, such as peak sound pressure, daily noise exposure level and weekly noise exposure level. It also includes exposure limit values and exposure action values:

- exposure limit values: \( L_{\text{Ex},8h} = 87 \text{ dB} \) and \( p_{\text{peak}} = 200 \text{ Pa} \)
- upper exposure action values: \( L_{\text{Ex},8h} = 85 \text{ dB} \) and \( p_{\text{peak}} = 140 \text{ Pa} \)
- lower exposure action values: \( L_{\text{Ex},8h} = 80 \text{ dB} \) and \( p_{\text{peak}} = 112 \text{ Pa} \)

As a result of implementing the directive 2003/10/EC by Poland, the Regulation of the Minister of Economy and Labour of 5 August 2005 [14] on safety at work regulations for works connected with exposure to noise or mechanical vibration was implemented. In addition to the health and safety requirements regarding mechanical vibration, the regulation defines the requirements regarding noise. It includes a definition of noise, conduct guidelines in case exposure action values are exceeded and obliges an employer to take action to reduce occupational risk. It defines exposure action values:

- for noise exposure level referred to an eight-hour work day or noise exposure level referred to weekly period of work – the exposure action value shall be 80 dB,
- for C-weighted peak sound level – the exposure action value shall be 135 dB.

However, the detailed methods for taking the measurements are defined by Polish standards:

a) PN-ISO 9612 [10]. The standard describes the determination of the acoustical quantities, especially the type and locations of sound pressure level measurements to be conducted and the time sampling required. Special requirements concerning infrasound and ultrasound exposure are also included in the standard. This standard does not specify acceptable noise limits.

b) PN-81/N-01306 [11]. The standard provides general requirements for measurement methods of machines, processing equipment and measurement methods of noise in location occupied by people. It provides the quantities that should be measured to get necessary information on noise for its evaluation. Those quantities include: sound level, sound power level \( L_{\text{W}} \) and equivalent sound level.
c) PN-N-01307 [12]. The standard provides acceptable levels of noise in the workplace in consideration of hearing protection and requirements for taking measurements. The standard applies to all types of noise with the exception of infrasound and ultrasound noise. The acceptable noise levels at workplace are as follows:
- 75 dB in direct control cabins, laboratories with noise sources, rooms with computing machines, typing machines and other rooms of similar designation,
- 65 dB in dispatch, observation and remote control cabins, in rooms for carrying out precision works and other rooms of similar designation,
- 55 dB in administrative rooms, design office rooms, theoretical study rooms, data processing rooms and other rooms of similar designation.

d) PN-90/S-04052 [13]. The standard provides general requirements concerning noise level testing inside passenger cars, trucks and buses. It specifies allowable noise levels inside the vehicles while driving. The levels are as follows:
- 79 dB – for passenger cars,
- 80 dB – for long trucks with sleeping facilities, international trucking, coaches,
- 82 dB for trucks and city buses.

e) PN-92/K 11000 [5]. The standard provides guidelines for the tests concerning acoustic parameters of noise generated inside tractive vehicles, coaches and noise emitted into the environment. It specifies allowable noise levels inside the rail vehicles while driving. The levels are as follows:
- 78 dB – at driver and assistant driver’s seat of the tractive vehicle,
- 70 dB – in rooms of tractive vehicles and coaches for transport of passengers and running in suburban and local trains,
- 78 dB – in second class compartments of coaches designed for running in long distance trains and in service compartments of postal, baggage and restaurant cars,
- 65 dB – in first class compartments of coaches designed for running in long distance trains, sleeping and saloon cars.
- Inside the rail vehicles at standstill (without passengers):
  - 55 dB – in the case of noise generated by ventilation and heating equipment in the first class passenger cars, sleeping, couchette, restaurant and saloon cars,
  - 60 dB – in the case of noise generated by ventilation and heating equipment in the second class passenger cars and other vehicles where there are rooms for passengers.

f) PN-ISO 1999:2000 [9]. The standard describes a method for calculating the expected noise-induced permanent shift in the hearing threshold levels of adult populations due to various levels and duration of noise exposure. It provides the basis for calculating hearing handicap according to various formulae.

On the basis of the above documents, the test procedure for the road-rail vehicle IVECO-TC-2 in normal operation conditions was prepared.

SUMMARY

In the above analysis of regulations and standards there are not any document that regulates directly vibration and noise phenomenon in the road-rail vehicles although that type of vehicles have been known for a long time. To perform an experiment that will allow evaluating an influence of vibration and noise on human body, the general documents on safety at work and applied standards relating to railway and road vehicles should be used.

Lack of the suitable standard results from both complexity of vibration and noise phenomena and specific nature and working environment of the road-rail vehicles.
BADANIA KLIMATU AKUSTYCZNEGO
POJAZDU SZYNOWO-DROGOWEGO
W WARUNKACH NORMALNEJ EKSPLOATAJCJI
– ANALIZA PRZEPISÓW

Streszczenie
Artykuł dotyczy problemu pomiaru drgań ogólnych, miejscowych oraz hala
sus występujących podczas eksploatacji pojazdu szynowo-drogowego. Omówiono za
lezy dokumenty związane z pomiarem czynników wibroakustycznych wewnętrz pojazdu dwudrogowego podczas jazdy oraz postoju w aspek-
tcie ich oddziaływania na organizm człowieka.

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