Research on measurement of electromagnetic fields generated by electric and combustion powered rolling stock.

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Abstract. Axle counters are more and more often applied in train detection systems. The wheel sensor is a main part of each axle counter system. In parallel, more and more complex railway vehicles, especially traction ones, are a potential source of interferences influencing the operation of these train detection systems. It is the reason to verify the electromagnetic compatibility (EMC) between the signalling equipment, particularly train detection systems and new vehicles in the process of obtaining the permission for their exploitation. The measurement of interfering magnetic fields generated by vehicles is one of tests to be carried out. For the simplification and unification purpose of the applied interference test methods the EN 50238 standard and TS 50238-3 technical specification were developed. The specification defines unified testing procedures. However, it is necessary to verify if it may replace different testing methods used in particular European states. It is the goal of the European research project financed from the TEN-T network resources.

1 Introduction

The widespread use of metering systems for track vacancy detection by various railway managements has highlighted problems of these devices' resistance to interferences generated by rolling stock. Another related aspect is also equipping rail vehicles with electric and electronic equipment with extensive structure. The experience of many railway managers shows that modern vehicles can cause disturbances in the axle counters' operation. Therefore the standardization activities on the European level have been ongoing for many years in order to unify and simplify procedures related to particular rolling stock types' placing in service on the European railway network. These efforts are also largely focused on the so called process of frequencies management resulting in the determination of maximum levels of interference for particular frequency bands.

The legal conditions in the field of railway interoperability require rolling stock manufacturers to meet the requirements specified in the Technical Specifications for Interoperability (TSI). The main document concerning the subject discussed in this article which defines the requirements for rolling stock is the document ERA/ETRS/033281, which presents, among others, limits of magnetic field strengths for AC traction and the method of measuring these fields. It is worth noting that currently there are no uniform European requirements regarding the limits of magnetic fields for the DC traction system, they are so-called open points whose requirements are defined at the level of the national law.

Maximum levels of electromagnetic interference within the scope of national requirements are defined in the project of the Railway Research Institute No. 4430/10 "Determination of maximum levels and interference parameters for railway signalling equipment", while in the European law these levels are included in the technical specification CLC/TS 50238-3:2013: "Railway applications. Compatibility between rolling stock and train detection system - Part 3: Compatibility with axle counters" [8] and PN-EN 50592:2017-04 "Railway applications - Testing of rolling stock in terms of electromagnetic compatibility with axle counters" [6]. Issues generally related to the subject of compatibility regarding the interaction of rolling stock with train detection devices are also defined in the following standards: PN-EN 50238 and PN-EN 50617-2:2015-12 "Railway applications - Technical parameters of train detection systems concerning the interoperability of the trans-European rail system - Part 2: Axle counters" [7].

2 Methodology of measurement

In compliance with the provisions contained in the ERA/ETRS/033281 document, PN-EN 50592:2017-04 and PN-EN 50617-2:2015-12 standards, measurements of magnetic fields generated by rolling stock should be carried out with a standardized antenna (length 15 cm, width 5 cm and height 5 cm) (Fig. 1) independently for the three measuring planes: X, Y, Z (Fig. 2). The maximum values of magnetic field strength from traction vehicles are determined for three frequency bands: 27

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kHz – 52 kHz, 234 kHz – 363 kHz and 740 kHz – 1250 kHz.

Fig. 1. Recommended dimensions of measurement antenna [8].

Fig. 2. Method of mounting the measurement antenna [4].

The Railway Research Institute has measurement equipment that meets the binding European requirements for this type of research. The measuring equipment includes (Fig. 3): portable laptop computer with data processing and archiving software, two measurement antennas, three oscilloscope cards, two TNB modules with built-in impedance transformers, USB hub with external power supply, measuring leads.

Fig. 3. View of the magnetic field test stand (laboratory) [2].

The tests of electromagnetic fields consist in passing a particular vehicle over measurement antennas installed in the track, as shown in figure 4, on which axle counters are installed or will be installed, and the measurement of the generated magnetic fields values. The tests are carried out in various vehicle operation configurations, such as: traveling at various speeds, starting, electrodynamic braking, travels with on-board devices

activated (air conditioning, heating, etc.). Voltage values induced in antennas during the passage of the tested vehicle are recorded on the above-mentioned oscilloscope cards. The recorded results are then sent to the measuring computer, where the FFT analysis is successively carried out using specialized software. This analysis results in acquiring characteristics of the generated magnetic fields values as a function of frequency, which were compared with the limit values determined for each of the measured planes, in accordance with the previously mentioned normative requirements.

Fig. 4. Measurement antennas mounted in a railway track [3].

Two measuring antennas largely reduce the number of performed travels and allow a comprehensive assessment of the tested rolling stock, regardless of the possible asymmetry of the location of the interference source on the vehicle in relation to the track centre, which is particularly important during tests conducted on the railway route.

Examples of tests carried out for a locomotive operated in a 3 kV DC power supply system and in diesel traction are presented below. These tests concerned the assessment of meeting the requirements in the process of vehicle approval for the network managed by PKP PLK S.A.

3 Test results

The test stand was located on the Test Track Centre of the Railway Research Institute in Żmigród. The measurements were carried out for the basic operational states of the traction locomotive (starting, braking, driving at a constant speed) and for the cases of the absence of the vehicle near the measurement antennas (the so-called background measurement). Figure 5 presents examples of results of the background measurement recording, whereas figure 6 shows the magnetic field strength recorded during the start-up of the locomotive in the electric and diesel traction. The red colour indicates the limit values of magnetic fields compliant with the requirements of the ERA/ETRS/033281 document and the [6] standard, while the measured values are shown in blue.

Fig.5. Magnetic field strength in the X, Y, Z planes recorded in the track without a locomotive (background measurement) [1].

Fig.6. Magnetic field strength in the X, Y, Z planes recorded in the track during a start-up of a diesel-electric locomotive [2].

5 Conclusions

The examples of test results presented in the article confirm that they are different for the same traction vehicle for runs in electric and diesel traction. This

proves the necessity to perform measurements of the impact of magnetic fields emitted by diesel-electric traction vehicles both in the electric and diesel traction, as they constitute an essential point of electromagnetic compatibility tests for rolling stock running on railway tracks equipped with train detection equipment. It is reasonable to carry out tests on the emission of magnetic field strengths in the case of introducing new and modernized rolling stock into service. This allows eliminating sources of interference from vehicles, exceeding the maximum values [9], already at the stage of approval tests.

The presented test method complies with the requirements in force and allows for a precise assessment of the measured values in relation to the binding maximum values. The Railway Research Institute has calibrated measurement equipment, a test stand on the test track circuit and a team of qualified employees with extensive experience in the mentioned above research.

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