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ELECTROMAGNETIC COMPATIBILITY OF RAILWAY TRAFFIC CONTROL DEVICES (SRK) WITH OTHER RAILWAY EQUIPMENT

This paper presents a general description of issue of electromagnetic compatibility of railway traffic control devices with other railway equipment. The criteria of noise assessment for the purpose of electromagnetic compatibility evaluation are described. Characteristics of sensitivity for various railway traffic control devices are shown. Acceptable noise parameters for Polish State Railways (PKP) and selected railway management are quoted.

KOMPATYBILNOŚĆ ELEKTROMAGNETYCZNA URZĄDZEŃ SRK Z INNYMI URZĄDZENIAMI KOLEJOWYMI

W referacie przedstawiono ogólny opis problematyki kompatybilności elektromagnetycznej urządzeń sterowania ruchem kolejowym z innymi urządzeniami kolejowymi. Opisano kryteria oceny zakłóceń dla potrzeb oceny kompatybilności elektromagnetycznej. Pokazano charakterystyki wrażliwości urządzeń srk oraz przedstawiono dopuszczalne parametry zakłóceń dla PKP i wybranych zarządów kolejowych.

1. INTRODUCTION

Introduction to high speeds i.e. over 160 km/h, in Polish State Railways (PKP) requires use of new rolling stock, both traction devices and wagons. The modern rolling stock (with much higher power) differs in quality from the traditional one, where electric and electromagnetic compatibility is concerned. Traction vehicles are provided with semiconductor control devices and the wagons are equipped with so called static converters, also involving use of semiconductors. Besides the obvious advantages, implementation of semiconductor regulators in the traction vehicles and wagon converters causes growth of disturbances caused by electric traction lines in the railway communication network, railway traffic control devices, and public telecom network, especially in the telecom lines located in the electric traction influence range.

All railway traffic control devices (SRK) are located nearby the railway tracks; certain of them are connected directly to the rail continuity. They are subjected to serious influence of other railway devices, and above all devices related with electric traction. Mechanism of influence is shown on Fig.1. Reference is made to the interaction on the railway traffic control equipment of disturbances generated by the electric traction devices, among others:

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- traction vehicles (locomotives),
- traction substations,
- wagon static converters,
- auxiliary devices on the traction rolling stock fed directly from traction network.

The above named sources of disturbances do not have similar share in the global level of disturbances. This is due mainly to their power as generally the value of alternate component is proportional to power.

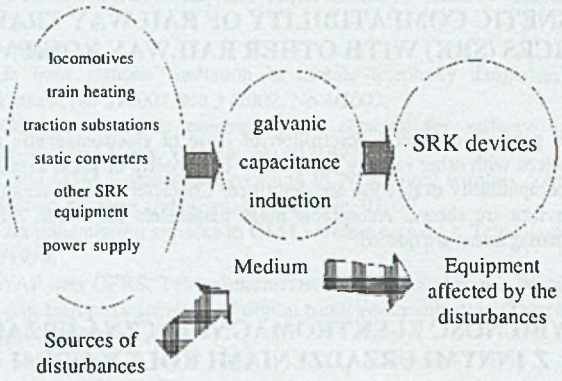

Fig.1. Diagram of disturbance influences

The railway traffic control devices ensure the safety of railway traffic. Their vulnerability to the disturbances has to be small enough to not cause disruptions in the train traffic or lead to a catastrophe.

Depending of results of influence, the faulty operation may be divided into:

- Disturbing – it means those the safety conditions are maintained, and the effect of disturbance influence is reduced throughput of the railway lines, for example, additional unplanned train stopping (power losses);
- Dangerous – it means those the safety conditions are not maintained (for example there is a release light instead of red light on track signal). This situation is unacceptable, as there exist a potential danger of catastrophe.

In order to ensure electromagnetic compatibility of SRK devices with together railway equipment it is necessary to perform the following works:

- Determination of values of acceptable disturbance parameters for disturbed devices;
- Determination of values of acceptable disturbance parameters for disturbing devices;
- Site measurements of disturbances generated by for example locomotive to the traction line;
- Checking tests of disturbance influence on the equipment.

2. CRITERIA OF DISTURBANCE ASSESSMENT

One of the issues influencing the qualitative assessment of the SRK devices is their vulnerability to the external disturbances

We may discern three types of effects caused by external disturbances:

a) Operation of receiver exclusively under the influence of disturbing signal;
b) Receiver's failure to operate in the presence of operating signal and disturbances;
c) Permanent damage of the receiver.

The effect of disturbance influence named in item a) is unacceptable as it may lead to disaster, whereas other two lead to the operational perturbation (item b) or unnecessary losses (item c).

Distribution of disturbing signals and track circuit signals for the cases discussed above are shown on Fig.2.

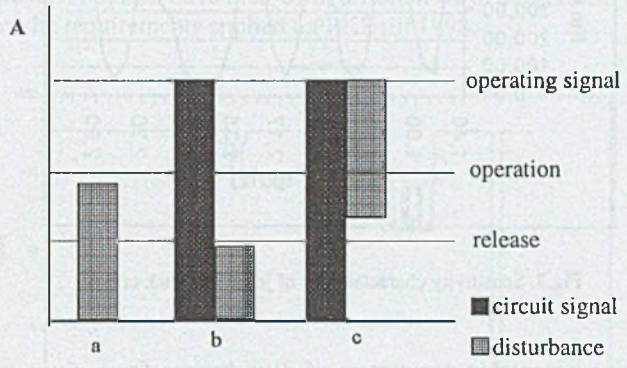

Fig.2. Distribution of signals at the disturbances

Each receiver of the SRK devices has its own sensitivity characteristics. In order to define it, we have to determine at which threshold values the receiver operates correctly. The most important are such parameters as:

- amplitude,
- frequency,
- duration of the signal.

Characteristics of disturbance sensitivity of a SRK device receiver is determined through setting of such parameters as during the determination of sensitivity of disturbing device causing its incorrect operation with presence of the operating signal, as well as determination of parameters that might lead to its failure.

Characteristics of sensitivity and vulnerability of the SRK device receivers constitute a basis for determination of acceptable disturbance levels and selection of criteria of their evaluation.

Fig.3 shows the instances of characteristics of receiver's sensitivities for joint less track circuits.

The basic criterion for assessment of disturbance is its damaging effect for the given type of the SRK equipment. It is of course a very general criteria that should be parameterised. As a start point we should assume the characteristics of sensitivity and vulnerability of the SRK devices.

Then we have to assume appropriate margin coefficients to determine the required minimum offset between the sensitivity and vulnerability characteristics and disturbance parameters.

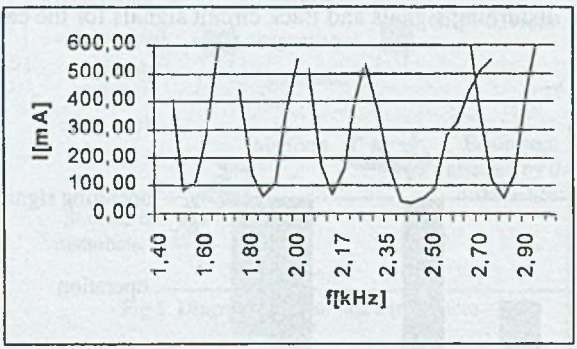

Fig.3. Sensitivity characteristics of joint less track circuits

We will thus receive acceptable parameters of disturbances for a given type of the SRK equipment. The issues to be taken into account during analysis of disturbances in the SRK equipment are both mechanisms of intrusion of disturbances and mechanisms of totalizing of disturbances from several sources (including also resonance in traction lines). In a simplified approach the disturbances generated in a traction line may appear at the receivers' inputs of the SRK equipment by two ways: galvanic and induction one. Galvanic intrusion of disturbances takes place in these SRK devices that are directly connected to the traction network (such as track circuits) whereas in other equipment the influence is of inductive character.

From the practice we know that the level of disturbances transmitted to the receivers' inputs by galvanic way is considerably higher than the inductive ones.

The disturbances appearing at the input of SRK device receiver are usually a sum of disturbances generated by various sources. They may be sources with identical characteristic (such as several wagon converters) or with different ones (such as locomotive and wagon converters)

Based on literature data and results of own researches we may assume that the sum of disturbances from electrical traction lines is of geometric character. This fact is of importance when determining acceptable parameters of disturbances for a single source of disturbances (locomotive, wagon converter).

Summarising, when we have sensitivity and vulnerability characteristics of receivers in SRK equipment and assume offset coefficients we may determine acceptable parameters of disturbances for the disturbance sources (such as wagon converters) taking into account the way of summarising the disturbances from several sources.

3. ACCEPTABLE DISTURBANCE PARAMETERS

The issue of traction rolling stock influence over the railway traffic safety devices exists in all the railway management. Presently no official standards are present both in Railway Managements of UIC and OSZD and in the European Union countries. Theoretically, there exists the European Standard developed by CENELEC EN50121 that does not provide any data concerning influence on the SRK devices. This standard describes acceptable parameters of disturbances as applied by each Railway Management based on their own requirements. For this reason, the Railway Managements use not only various values of acceptable disturbance parameters, but also have their own, different ways to establish them.

Fig .4 shows the requirements applied on PKP till 1998.

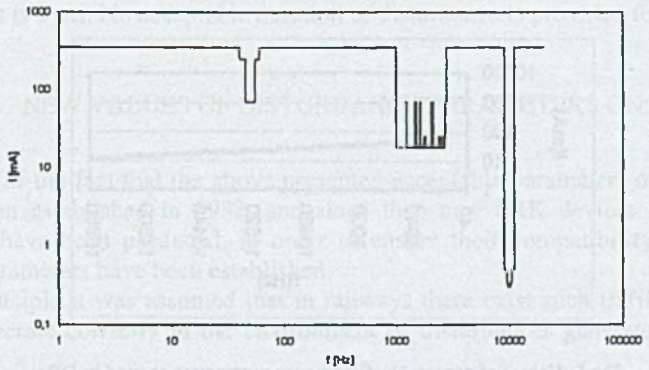

Fig.4. Values of acceptable disturbance parameters as used in PKP till 1998

These requirements are divided into three ranges:

- 40 – 60 Hz,
- 990 – 2750 Hz,
- 9000 – 11000 Hz.

In the first and second range the acceptable duration of disturbance is 150 ms, whereas in the third range it is 5 ms. Besides the ranges indicated the acceptable disturbance current amounts to 350 mA regardless of duration of the disturbance.

Fig.5 shows the requirements applied on SŻD (Russia).

Fig.5. Values of acceptable disturbance parameters as used in RŻD

The requirements do not provide for acceptable disturbance duration times.

Fig.6 shows the requirements applied on German railways (DB) and Fig.7 shows the requirements applied on Austrian railways (OBB).

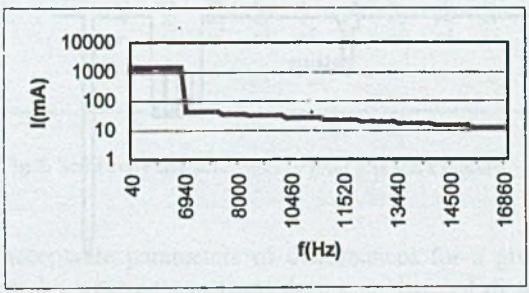

Fig.6. Values of acceptable disturbance parameters as used in DB

These requirements are divided into two ranges:

- 40 – 102 Hz,
- 6940 – 16860 Hz,

In the first range the acceptable duration of disturbance is 500 ms, whereas in the second range it is 40 ms.

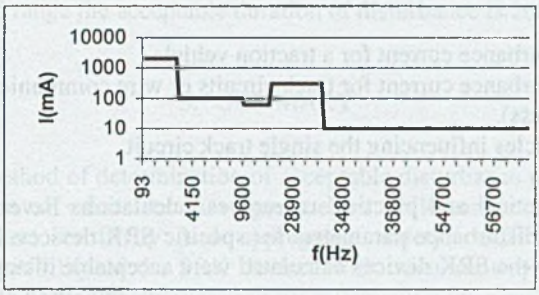

Fig.7. Values of acceptable disturbance parameters as used in OBB

These requirements are divided into three ranges:

- 93 – 106 Hz,
- 3850 – 10100 Hz,
- 28 - 58 kHz.

In the first range the acceptable duration of disturbance is 3000 ms, whereas in the second range it is 5 ms. No acceptable duration of disturbance is provided for the third range.

4. NEW VALUES OF DISTURBANCE PARAMETERS ON PKP

Because of the fact that the above presented acceptable parameters of disturbances for PKP have been established in 1982, and since then new SRK devices and new traction vehicles may have been produced, in order to ensure their compatibility, new acceptable disturbance parameters have been established.

As a principle it was assumed that in railways there exist such traffic control devices that should operate correctly in the environment of disturbances generated by the traction vehicles.

Acceptable disturbance parameters have been determined for track circuits as the most vulnerable to the disturbances generated by electrical traction equipment. As a beginning point assumed is the above-described vulnerability of track circuits and the determined offset values.

The theoretical and practical tests show that the acceptable disturbance parameters for a single traction vehicle may be determined as a geometrical sum (summary disturbance current equal to square root of sum of squares of disturbance currents from each vehicle) of disturbances generated by the traction vehicles located at the same power supply section and influencing the track circuit. It was assumed that not more than 4 vehicles could influence the track circuit at the same time.

Thus, acceptable disturbance current for a traction vehicle amounts to:

$$I_{dpoj} = \frac{I_{dop}}{\sqrt{n}} = 0{,}5 \bullet I_{dop} \qquad (1)$$

where:
I_{dpoj} - acceptable disturbance current for a traction vehicle,
I_{dop} - acceptable disturbance current for track circuits or wire communication devices (whichever is less),
n - number of vehicles influencing the single track circuit.

Based on theoretical and practical researches calculations have been made to obtain values of acceptable disturbance parameters for specific SRK devices. Based on disturbance parameters values for the SRK devices calculated were acceptable disturbance parameters for traction vehicles.

Fig.8 and Fig.9 show acceptable disturbance parameters for a single traction vehicle (such a locomotive).

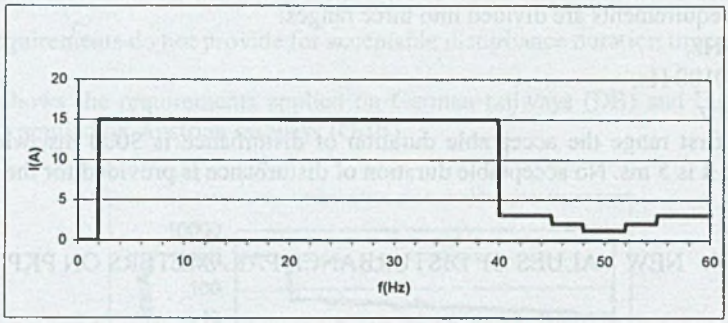

Fig.8. Values of acceptable disturbance parameters for locomotive (range 0-60Hz)

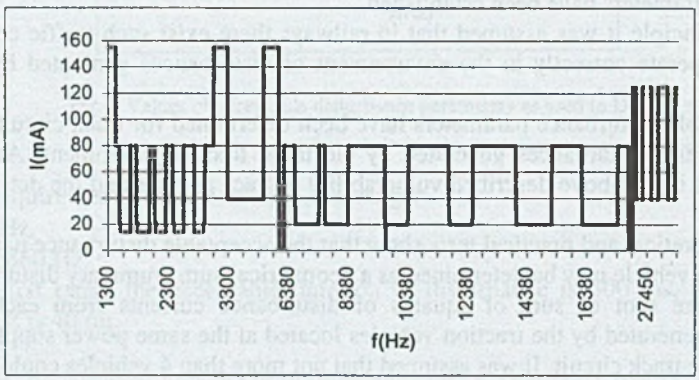

Fig.9. Values of acceptable disturbance parameters for locomotive (range 1,3-33,5 kHz)

These requirements are divided into three ranges:
- 0– 60 Hz,
- 1300 – 33 500 Hz,

In the first and second range the acceptable duration of disturbance is 200 ms.

5. SUMMARY

The assumed method of determination of acceptable disturbance parameters enables an accurate determination of values for these parameters while maintaining the real railway traffic control devices sensitivity and appropriate safety coefficients. This ensures electromagnetic compatibility of the SRK devices with other railway equipment and with traction rolling stock in particular.

BIBLIOGRAPHY

[1] BIAŁOŃ A. i inni, "Opracowanie dopuszczalnych parametrów zakłóceń dla urządzeń srk, łączności i pojazdów trakcyjnych. CNTK, Warszawa 1999.

[2] BIAŁOŃ A., "Ustalenie dopuszczalnych parametrów zakłóceń od prądów trakcyjnych w obwodach torowych stosowanych na PKP". CNTK, Warszawa 1982.

[3] БЯЛОНЬ А., Значения допускаемых параметров помех для тяговых поездов. Вестник ВНИИЖТ. 5/2001.

[4] BIAŁOŃ A., SZELĄG A., ZAJĄC W., Disturbing Influence of Electric Traction Vehicles on Signalling and Control Circuit on Silesian Regional Railway. (p. 222-224); International Symposium on Electromagnetic Combatibility and Electromagnetic Ecology EMC 95 EME, 1995, Saint-Petersburg.

[5] "Berechnungsmethoden fur die Bestimmung der Storungen von Schwachstromanlagen. Uberschlagsverfahren zur Abschatzung der (psophometrisch bewerten) Querspannung und seine Vervendung fur die Lokomotivenversuche in Velim".Utrecht April 1991. ORE RP-3 (A-171).

Reviewer: Prof. Zbigniew Ginalski