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Does complying with the norms for railway sleepers with anchoring ensure that the requirements of the standard for the track are met?

Abstract: The paper points out that compliance with the requirements of standards in the scope of the electrical parameter of the railway sleeper with the attachment of rails does not directly lead to meeting the requirements of the standard for a track electrified with DC current, which were made of such sleepers.

Keywords: Open construction tracks; Electric resistance of the railway sleeper; Conductance of the rail transition – ground; Track circuits; Stray currents

Introduction

The standardization includes a number of technical requirements, including electrical ones, for the components and the total product, which is the track. The paper draws attention to the electrical parameters of the fastening and sleeper system and to the requirements related to the use of the track with the selected fastening system for the construction of a line electrified with stray currents. The paper shows that in the case of tracks electrified with stray currents, the minimum requirements specified in the standards should be increased in relation to the fastening system proposed for building in such a track on a single sleeper.

Classic construction track

The classic railway track, and sometimes also a tramway built in crushed stone, is of open construction, i.e. the rail is visible and the way its foot is attached to the railway sleeper. In the open construction tracks, the upper surface of the submerged sleeper is also visible. Thanks to this, the observer is able to indicate whether the sleepers are wooden or concrete. If the markings required by the standard are visible on the base, it can be determined whether the concrete base is reinforced and how. Fastening the rail to the sleeper is to ensure that a number of requirements are met, including demonstration of specific electrical resistance. In the case of wooden sleepers, which were first used in the construction of railway tracks, this resistance ensured adequate drying and saturation of the wood of the sleeper and the smoothness of its surface.

Standards requirements for the railway sleeper with a fastening system

The rails are used as electrical wires in the track circuits created from them for the purposes of signaling, control and driving safety of not necessarily electric vehicles moving on them. Track circuits distributed along the route provide track signaling and vehicle traffic control systems. Rails as electrical wires require isolation from each other, and thus minimal electrical resistance between one rail and the other [4, 8]. This resistance is the insulation of the wires relative to each other as well as to the environment, especially crushed stone, implicitly soil - electrolyte. According to [4], this resistance is measured in accordance with [3] and the requirements are defined in the next standard [5]. The above division results from the fact that in operation there are a number of different design solutions for attaching the rail to the railway sleeper. The resistance test was normalized - standardized for all existing and possible future systems of fastening the rail foot to the railway sleeper. In [3] the requirements to be met by the tested object are defined - the railway sleeper with rail sections attached to it set in a certain way under the defined nozzles spraying the railway sleeper during tests with water in the amount of about (7 ± 1) l / min for 2 minutes. The water used for the tests must be of electrical conductivity within (20 - 80) mS/m at 25^{o}C [6]. Electric resistance is measured by alternating current from a source with a voltage (30 ± 3) V RMS effective value and frequency (50 ± 15) Hz by the technical method - voltmeter and ammeter for large resistances. Since the AC resistance is used for testing, it should be stated that from an electrotechnical point of view we determine the impedance between the rails of this physical object. The tested railway sleeper with attached rail sections is set on insulating supports enabling free runoff/dripping of water onto the plane below with the drain. The standard [3] also presents the typical nature of resistance changes during the measured/recorded two-minute water test. The method of correction calculations for standard water conductivity 33 mS/m is also given, depending on the conductivity actually occurring during the test. From the point of view of the observer of the studied phenomenon, when the water falls on the object, the insulation is shunted between the rails attached to the railway sleeper. The thinner the water layer and the weaker its adhesion to the fastening materials and the sleeper between the rails, the chances of maintaining insulation with high resistance value between them increase.

Thanks to this test, the transition resistance between two rails in the track on one sleeper is determined in the event of "normalized" precipitation in the form of rain.

The standard [5] regarding the operational requirements of fastening systems with respect to the electrical resistance of the fastening system and the sleeper states that "if the user requires that the fastening system provide electrical insulation, it should not be less than 5 kΩ, if measured in accordance with [3]. The user can specify a higher value in relation to specific track circuits."

Requirements for a single-track electrified with direct current

The standard [7] regarding tracks electrified with direct current sets the requirement for the permissible unit conductivity of the ground rail crossing. The standard distinguishes between two types of track: previously given open construction and closed construction track, i.e. a completely built track. For the observer, only the head of the rail is visible, but in [7] it is clearly stated that only its sliding part, on which the wheel of the vehicle moves. In a built-up track, it is permissible to see a larger part of the head. Undoubtedly, the tracks at the crossings are closed = completely built-up, because the crossing surface is at the level of the rail head raceway. In the case of open construction tracks in the standard [7], a requirement is set for the unit conductivity of the ground rail crossing for a single track not exceeding 0.5 S/km. In the Polish standard [2] and the technical Polish vocabulary, it was preferred to specify the ground rail crossing resistance, which is expressed in units of Ωkm. Thus, the ground rail unit transition resistance is the inverse of the ground rail unit transition conductance.

The standard [7] of 2011 provides two methods for track assessment/testing, regardless of its construction. The previous method required the separation of the tested section from the entire track system, which in the case of a railway track with track circuits with glands and insulating connectors does not create other problems/organizational problems to perform the tests, and during their implementation there may be doubts as to the effectiveness of insulation on connectors. In tram tracks, this method can be used only during track repairs. For the purpose of measurement, a system should be built forcing the flow of current between the separated section and the remaining track network, as well as measuring or recording the impact of the current excitation of the measured value on the changes in the electrical (electrochemical) potential of the separated section of rails.

The second method uses the registration of the rail potential and the potential gradient perpendicular to the track during normal operation of the tested track. To determine the local unit transition conductivity, knowledge of soil resistivity, track geometry and the distribution of measuring electrodes are required. Depending on whether the tested track is a one or two-track line, we use the appropriate formula given in the standard [7].

There are no requirements in the standard [7] regarding the weather conditions in which tests should be performed. However, the use of copper sulphate half-cells as the reference electrode in both of these methods limits the possibilities of testing to temperatures above zero. The work possibilities of modern recorders no longer impose such stringent temperature requirements on us.

Track geometry and its resistances

For the cooperation of the railroad with the vehicle, track geometry is a key issue, requiring builders to master and use appropriate technology to meet the required regimes and deviations. In the case of electrical parameters of such a track, the distance between sleepers appears to be one of the important issues. In a classic track with standard gauge gravel with "concrete" sleepers - made of prestressed concrete or reinforced without tension or only concrete - there is a distance of 75 cm between the railway sleeper axes. If the ballast after embedding the sleeper is not on the rail foot, we will obtain insulation between the rails as a resultant of the number of sleepers with a resistance of not less than 5 kΩ connected in parallel on a given track section. This means that the resistance measurement between the rails made on a section of the track grate - two rails attached to 100 sleepers meeting the requirements of the standards [3, 4 and 5] should show a value greater than 500 Ω, regardless of the method or device used measurement of resistance maybe beyond the bridge systems that are sensitive to external interference, e.g. from stray currents. If the measured value is equal to or less than 500, then - unless the measurements were made during rain - it means that one of the sleepers and fastenings did not meet the requirements of the standard, even in more favorable conditions for measuring the track section. The length of the track section with 100 sleepers is 75-76.5 m. A ten times longer section of the track should have a resistance above 50 Ω. The length of track circuits encountered in practice is in the range of 1000 sleepers, and therefore the expected insulation between the track circuit wires in conditions of heavy precipitation should not fall below 50 Ω.

It should be noted that on one kilometer of a track with sleepers laid every 75 cm, there will be 1333 sleepers altogether.

Earlier than the norm [7], the norm [2] only in the case of tracks in tunnels determined/defined the unit resistance of the track passage relative to the tunnel at the level of 20 Ωkm. In the scope of measurement, this standard allowed treating a section of track as an earth electrode, whose resistances should be determined - by default, at that time it was the use of the IMU device (Inductive Earth Meter), as we have an example in [9].

Built in the 80-90s of the 20th century in the metro section between Kabaty and Politechnika stations was equipped with a choke system of track circuits on an open construction track [1]. As a result, individual track sections separated by insulating joints could easily be separated. The grounding bus covering the entire length of this underground structure provides a relatively constant reference value when measuring the passage resistance of individual sections and track elements. This enabled testing of resistance between individual section rails and the grounding bus, as well as between short section rails and the bus, as well as between rails of this section if the track glands were properly disconnected. It was noticed that only in cases where the resistance of the rail sections relative to the bus was equal, the resultant track resistance was equal to half of this value, while the resistance between the rails was usually the sum of both values. If there was a difference in the resistance values of the bus rail between individual rails of a given track section, the resultant resistance for the track of these rails was always closer to the lower value of resistance, and between the rails, it was still the sum.

Transferring this observation to the foundation with fastening, it should be stated that the measurement made according to standards [3, 4 and 5] gives us information that only in one case will be compatible with track measurement using the method from the standard [6]. All sleepers on the tested track section must be identical and symmetrical in terms of electrical resistance. The resistance between rails measured on such a resistance symmetrical backing will be twice as high as the resistance of these rails relative to the ground (ambient - soil electrolyte)

Based on the above assumption, having 1 km of 1333 sleepers, each with resistance between rails of 5 kΩ or 2.5 kΩ relative to the ground, we will get the ground rail transition resistance of 2500/1333 ~ 1.875 Ω. Converting this into unit conductivity, we get 0.533 S/km and therefore this track will not meet the requirements of the standard [7].

Therefore, what should be expected the minimum value of resistance between rails so that a track with the same number of sleepers meets the requirements of the standard [7]. In this ideal case, 0.5 S/km will be obtained if the resistance between the rails on the sleeper will be 5,4 kΩ

The above case is perfect. In technical practice, we deal with tolerances - accuracy and repeatability in a series. The number of sleepers per 1 km of running track means that they are statistically checked even during production. The repeatability of the obtained technical parameters of individual sleepers and fasteners will be much greater with fully automated production using templates.

Testing the sleeper with rail fastening using the method of standards [3, 4 and 5] in the dry state and under rainfall and after wetting with water, we will not get unambiguous information about the electrically symmetrical distribution of resistance under each of these fasteners in the sleeper. But in cases when this resistance is dry and wet, it will be much higher than with water, the greater the probability that the resistance components under the fixings will be greater than 2.7 kΩ, which value at symmetry ensured compliance with the minimum required by the standard [7]. If the value of resistance between rails on the sleeper measured dry and after moisture is greater than the value of 5kΩ, then with the assumed tolerance of the performance of the sleeper there is a greater likelihood that the track with these sleepers will meet the requirements of the standard [7].

Finally, it should be noted that in practice a single ground fault in the track circuit does not cause an "emergency" state of operation in it, but for the passage of stray currents, it is unacceptable especially in tunnels and metro stations. The grounding of the second rail of this track circuit causes the SRK to fail. This experience makes it clear that in the case of sleepers with a "system" fault resulting, for example, from the form of the defect in the symmetry of resistance in the sleeper, and the same laying of these sleepers in the track will not harm the railway track circuits. However, this contributes to the possibility of non-compliance with the standard [7] by such track.

Source materials

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