# METHODS TO PREVENT ICING ON SYSTEMS OF CURRENT COLLECTION OF URBAN ELECTRIC TRANSPORT

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## ABSTRACT

*The harsh climate of the country imposes stringent requirements for all structures of equipment operated on rail transport. One of the adverse events is the formation of ice, fraught with increasing mechanical load on the structural elements of traction network, breach of electrical contact between the wire and the current collector, followed by arcing and burnout of trolley lines. Deicing on trolley lines and power lines is made by electrical, chemical and mechanical means. There are some negative aspects in the application of these methods: annealing danger, damage and deformation of wires, high energy consumption, low productivity, incomplete removal of ice. Many scientists deal with improvement of deicing methods with varying success throughout the time of electrification of railways. On the basis of performed tests the authors propose the use of a special durable coating to inhibit the formation of ice.*

## ENGLISH SUMMARY

**Background.**

*Traffic safety of trains and operational reliability of traction power are largely determined by state of catenary, which for technical and economic reasons, is built without a reservation. The largest number of failures occurs most often due to deficiencies in the operational work, deviations in the technical parameters of the system elements. However, it is essential that a significant portion of disorders is linked to external factors – operation conditions and environment.*

*Ice, as one of such factors greatly increases the load on the wire, and supports, especially in those cases where it is accompanied by a strong wind. In addition, ice on the trolley line can create considerable difficulties in the current collection, causing arcing at the point of contact «pantograph slide – trolley line», which under certain circumstances can lead to burnout of trolley line.*

*In the most dangerous, in terms of icing, region extends North-Caucasian railway. The analysis shows that 42% of electrified railways are in the danger zone. And in fact, about 19 thousand km – is the length of catenary with the strongest influence of ice.*

**Methods.**

*As part as the study the analysis of publications was made, which showed that the problem of icing has been and remains relevant. Noteworthy is the fact that a large number of methods for prevention and deicing on the wires are proposed, but each of them has its own drawbacks.*

*For example, there is a deicing device type NOG-6 for the treatment of trolley lines with a moving device, designed for mechanical removal of ice from trolley line [2]. The disadvantage is its low productivity, the possibility of damage and deformation of the wires in the process of removing ice. Any damage may result in a delay of trains and high economic costs. The same disadvantages are common to drums with pneumatic turbines [3].*

*The method is used, which involves removing ice from wires by applying to them a special lubricant [4]. Its application process is characterized by high labor intensity, it is necessary to interrupt the movement of trains. Lubrication must be done in advance, before the formation of ice, it is fragile, easily removed from wires with pantograph slides, so throughout the season of ice formation it needs periodic renewal.*

*Summarizing the noted facts, the general disadvantages of the methods are:*

*- risk of trolley lines' burnout;*
*-high power consumption;*
*- low productivity;*
*-incomplete removal of ice;*
*-risk of damage and deformation of trolley lines;*
*-violation of traffic schedule.*

**Objective.**

*In 2012, commissioned by the Academy of Electrical Sciences at Ural State University of Railway Transport in the science laboratory «Computer-aided design of catenary» characteristics of specialized protective coating having basically aluminum silicate were tested. The purpose of the study was to determine the possibility of applying the coating to protect the trolley lines and power lines [5, 6]. The experiment was conducted using the climate chamber type THV710 (Pic. 1).*

**Results.**

*Test objects were two samples of 1 m length of wires MF-100 brand, used as trolley lines and two samples of wires PBSM-70, A-95 and A-120 brands, which are applied both to catenary (as suspension strands), and power transmission lines. They were treated with the test material (Table 1). «Painting» of wires MF-100 brand was carried out only from the top, where there is no current collector as aluminum silicate has dielectric properties. The weight of each sample was determined in advance.*

*In the chamber THV710 at high humidity repeated raise and fall in temperature from 80 to 70$^0$C were conducted. At the end of the experiment, all wires were again weighed.*

*As a result, laboratory tests determined that the coating:*

*– Prevented the formation of ice on trolley lines and power lines;*

*– Retained properties of high strength and elasticity.*

*On wires, which were not treated with a material, presence of frost mist and ice coating was observed.*

*In general, the load of the weight of ice per one meter length of wire or cable in a cylindrical shape of its deposition is determined by the formula (1), where*

*$b_г$ – thickness of ice wall, m; $d_i$ – diameter of wire, m.*

*Estimated value of the thickness of ice wall is determined by (2), where:*

*$k_г$ – coefficient taking into account the actual wire diameter, the height of its suspension and recommendations for the consideration of local conditions; $b^н$ – thickness of ice layer, m.*

*Since with the use of a special coating ice formation is prevented, then in the calculations thickness of ice wall and the weight of ice on the strings can be neglected.*

*Slacks of catenary for the mode «ice + wind» is shown in Pic. 2.*

*In the absence of ice the value of slack with decreasing temperature will vary slightly.*

*In continuation of the experiment in March 2013 test material was tested under real conditions at the station «Osentsy» of Kungurskay electric supply distance. The* length of the test section was 2,200 meters (tracks № 6, 7 of receiving yard). Environmental temperature: $+6^0C...+8^0C$ day, $-3^0C... -5^0C$ at night.

*The selection of this station was made due to the fact that over the past five years there had been problems of icing in the winter, because at this station «steaming» operations of cars are undertaken.*

*To prevent violations of traffic schedule processing of trolley lines had been performed in the planned «processing window» on 6, 7 tracks of receiving yard for 2 hours in parallel with plant diagnostics of catenary.*

*Application of the proposed coating on the trolley line was conducted from automatrix of ADM type, at a speed of 5 km / h, with periodic stops, removal of voltage and grounding.*

*The proposed coating is applied only to the upper part of trolley lines, so on the basis of geometrical calculations arc length of the bottom part is subtracted from the total perimeter of a trolley line (Pic. 3).*

*where R – arc radius; n – central angle of the arc in degrees.*

*When the cross-sectional perimeter of the trolley line is* $P = 39,155 \cdot 10^{-3}$m, *perimeter of the covered surface will be* $18,74 \cdot 10^{-3}$.

*The total length of the station «Osentsy» is 15 km, and according to this, area of the covered surface of a trolley line will be equal to*

$S = P \cdot L = 281,17\ m^2$.

*The next stage is the determination of the volume of consumable material with a coating's thickness of 1 mm:*

$V = S \cdot h = 0,281\ m^3$.

*As a result, to cover the surface of the trolley line with the length of 15 km with a material thickness of 1 mm 281 liters of material are required.*

*Despite the seemingly large amount of material consumption, it is worth noting that it will be sufficient to carry out such activities one time in 15 years, as one of its properties is durability.*

*Use of the method of current collection system protection keeping a predetermined schedule of trains will make it possible to avoid:*

*– The cost of electricity (ice melting);*

*– The cost of the restoration work.*

*To automate the coating process it is proposed to apply the method of electrostatic spraying [7].*

*Pic. 4 shows the main components of the required equipment, which include:*

*– Spray gun;*

*– Particles of sprayed material (coating), falling out of the gun to the working surface;*

*– An ionization needle located inside the substance flow or near it;*

*– Working (coated) surface.*

*As it is shown in Pic. 4, the electric field generated between the ionizing needle and the grounded object, helps the charged particles move to a grounded work surface. The strength of the electrostatic field contributes to the fact that a larger percentage of the charged particles of sprayed material reaches the object, rather than fly past or is swept away by the flow of ambient air. In other words, the transfer efficiency of the substance in the spraying process is improved by using an electrostatic effect, as the electric field directs a greater amount of particles to the working surface.*

*Effect of electrostatics can be used in any spraying process for improving the transfer of material, that is achieved by applying a protective coating on any design of catenary. However, adding electrostatic does not make a spraying process 100% effective.*

*The most rational way is to work on the application of the proposed coating in spring and summer, at an ambient temperature of 0 to* $25^0C$, *when there is the best adhesiveness of the protective coating and structural surface.*

*The proposed material is suitable not only for wires of catenary and electric transmission line, but also for other structures exposed to the external environment, including the facilities of urban electric transport.*

**Conclusion.**

*Basing on the results of the study, the authors can conclude that the proposed method of protecting the trolley lines from icing fundamentally changes the existing approaches to combat this phenomenon, allows saving the train schedule, significantly reduces breakage of catenary's designs during ice-forming period and increases the operational reliability of the system with the applied coating to 10–15 years, facilitates the necessary control over state of power supply, reduces the risks of emergency situations at the electric transport.*

*Taking into account the climatic features of Russian regions, it is advisable to focus efforts on the development of an inventory of icing on railway structures affecting their load-bearing capacity, identify priority areas requiring the use of limiting materials. This will provide an opportunity to tailor the properties of used protective means to operating region, as well as to determine the optimal thickness of aluminum silicate layer.*

*Keywords:* *railway, urban electric transport, ice, contact wire, electrostatic method, aluminum silicate.*

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