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ANALYZING THE PROTECTION OF HEAT NETWORK PIPELINES

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Keywords: thermal power, corrosion, pipeline, electrochemical protection, atmospheric corrosion, corrosion damage.
Abstract. This paper analyzes the main types of corrosion, the degree of impact of corrosion damage to the metal of structures and facilities of heat networks due to chemical or electrochemical reaction with the environment. The main measures for the protection of heat network pipelines in underground laying from various factors that have a negative impact on their performance are presented.

АНАЛИЗ ЗАЩИТЫ ТРУБОПРОВОДОВ ТЕПЛОВЫХ СЕТЕЙ

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Ключевые слова: теплоэнергетика, коррозия, трубопровод, электрохимическая защита, атмосферная коррозия, коррозионное повреждение.
Аннотация. В данной работе произведен анализ основных видов коррозии, степень воздействия коррозионного поражения металла конструкций и сооружений тепловых сетей вследствие химической или электрохимической реакции с окружающей средой. Представлены основные мероприятия по защите трубопроводов тепловых сетей при подземной прокладке от различных факторов, которые осуществляют негативное влияние на их работоспособность.

As of today, the total length of heat networks in St. Petersburg is about 8.1 thousand km. Of these, 4.5 thousand km are managed by SUE “FEC of St. Petersburg”, 2.5 thousand km by JSC “Heat Network of St. Petersburg”, and 1.1 thousand km by LLC “Peterburgteploenergo”. 24% of the total length of heating networks are operated beyond the standard service life of 25 years. Over the next eleven years, the city plans to replace about 1.5 thousand kilometers of networks [1].

At the moment, when operating heat networks and planning preventive maintenance on heat networks, there is a need for a comprehensive assessment and analysis of measures to protect the heat network pipelines from defeat and harmful factors in the existing networks of the heat and power complex of St. Petersburg. Also, in temporary perspective, the aging of pipelines and fittings, which provides qualitatively industrial and social development of St. Petersburg, continues.

During operation the pipelines of heat networks are affected by various factors that have a negative impact on their performance.

Metal corrosion is a physical and chemical process that causes destruction of metal or change of its properties as a result of chemical or electrochemical impact of the environment. Chemical corrosion occurs under the chemical influence of the environment as a result of direct reaction of metals with non-electrolytes.

On trunk pipelines, pipelines of compressor and pumping stations the most common is electrochemical corrosion, which can be soil, atmospheric, ground or underground [2].

In soil corrosion, the electrochemical corrosion process on the surface of pipelines proceeds according to electrolysis. On the surface of underground metal pipeline in contact with soil electrolyte, corrosion micro and macro elements occur.

Corrosive microelements appear due to the heterogeneity of the microstructure of the surface of steel turbine pipelines: the presence of microparticles of different metals in the alloy (Fe, C, Mn, P, S, etc.), microinclusions of scale oxides, non-metallic microinclusions (dust particles, violations of the microstructure of the pipeline surface), microstructural physical and chemical heterogeneity of the soil composition (microinclusions of different densities, chemical composition, concentration) [3].

The current between cathode and anode flows in the external circuit (in metal) when electrons move from anode to cathode and in the internal circuit (electrolyte) when cations and anions move.

Atmospheric corrosion is a corrosion process that takes place in an air environment. Atmospheric corrosion is categorized into three types: wet, wet, dry. Wet corrosion is corrosion that takes place when the humidity of the environment is 100% and when the pipeline is in water. A characteristic sign of destruction is the presence of layers of corrosion products on the pipe. Wet – occurs at relative humidity below 100%. The outer surface is rough, heavily corroded with a large number of corrosion sores. Dry – occurs at low humidity: the surface is rough and there are practically no corrosion sores. Figure 1 shows wet rust, wet rust and dry corrosion.

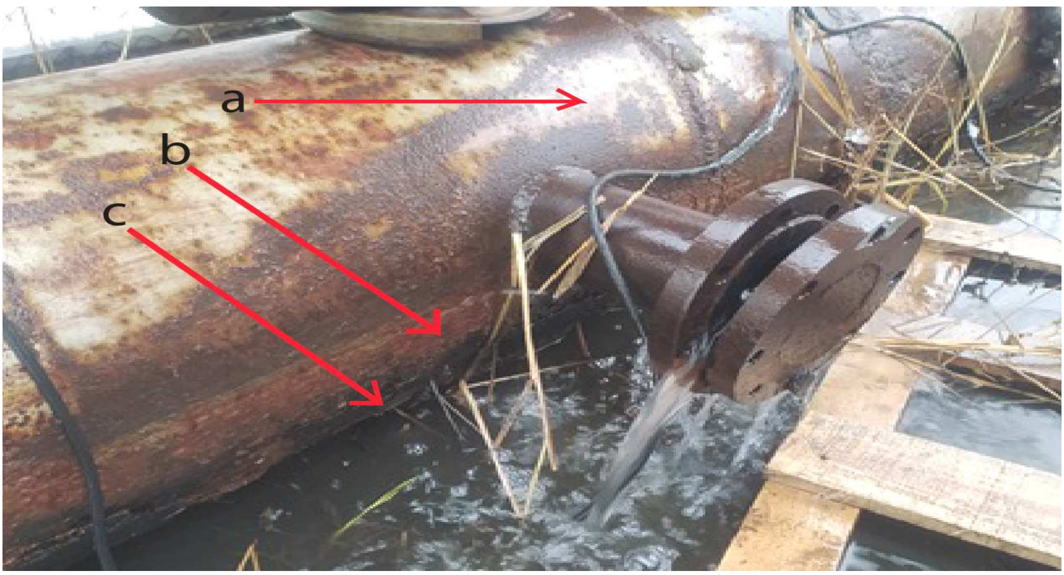

Fig. 1. Impact of atmospheric corrosion on the pipeline:
a – dry corrosion, b – wet corrosion, c – wet rust

Steam-water corrosion is observed when the insulation is periodically wet. In this case, due to temperature fluctuations of the outer surface within 70°, in places of alternate contact of metal with water there is a thinning of the pipe walls from the outer surface due to the effects of steam and water corrosion, as a rule thinning is subjected to the area of 3 and 9 hours (around the perimeter of the pipe), in appearance at steam and water corrosion observed evenly located on the surface of small ulcers.

Protection of heat network pipelines from corrosion is a very important task, the solution of which largely depends on the reliability of the entire district heating system in corrosion-prone conditions. There is one of the main ways to protect metals from corrosion – electrochemical protection (ECP). The principle of action of ECP of the external surface of the metal against corrosion is based on the fact that by shifting the potential of the metal by passing an external electric current, it is possible to change the rate of its corrosion. The relationship between the potential and corrosion rate is non-linear and ambiguous. ECP based on the application of cathodic current is called cathodic protection. In production conditions it is realized in three variants.

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The first variant: the necessary potential shift is provided by connecting the protected structure to an external voltage source as a cathode, and auxiliary electrodes are used as an anode. Figure 2 shows the features of electrical circuits of cathodic protection of heat pipelines.

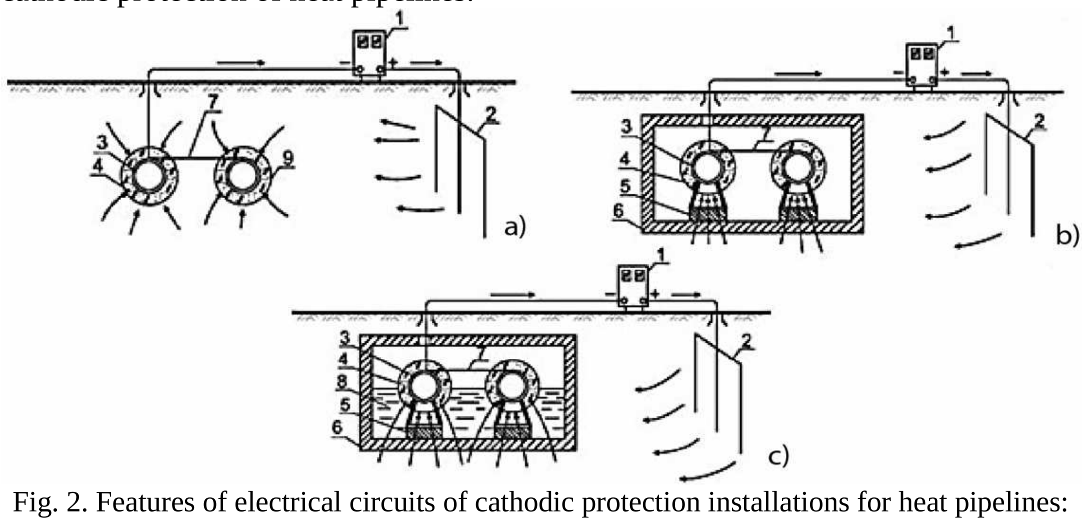

Fig. 2. Features of electrical circuits of cathodic protection installations for heat pipelines: a) ductless laying, b) in case of duct laying without flooding of the duct, c) in case of duct laying with flooding (skidding) of the duct;
1 – cathode station; 2 – anode earthing electrode; 3 – pipeline; 4 – insulating structure; 5 – support structure; 6 – channel; 7 – electric jumper; 8 – water (ground); 9 – ground

Cathodic polarization of an uninsulated metal structure to the minimum protective potential requires significant currents, so cathodic protection is usually used in conjunction with insulating coatings applied to the exterior surface of the structure to be protected. The surface coating reduces the required current by several orders of magnitude. During cathodic protection it is necessary to control the value of the maximum potential, because its too high value can lead to peeling of the insulation coating from the pipeline wall. Normative documents establish that the minimum protective potential for heat networks is equal to 1.1V, and the maximum potential is 2.5V in the negative side in relation to a non-polarizing copper-sulfate reference electrode. Such values must be ensured over the entire length of the protected area, and this is achieved the better the metal is insulated from the ground.

The second option: galvanic (or protector) protection. The principle of its operation is based on the fact that different metals are characterized by different values of standard electrode potentials. Cathodic polarization of the protected structure is achieved through its contact with a more electronegative metal. The latter acts as an anode, and its electrochemical dissolution ensures the flow of cathodic current through the protected metal. The anode itself, made of magnesium, zinc, aluminum and their alloys, is gradually destroyed. The advantage of protector protection is that it does not require an external voltage source, but this type of protection can be used only on relatively small lengths of pipelines (up to 60 m), as well as on steel cases.

The third option: to protect pipelines of heat networks from external corrosion under the action of stray currents, electric drainage is used. Drainage is a connection by a metal conductor of the area from which these currents drain. At a large distance to the rail, when such drainage is difficult to realize, an additional cast iron anode is used, which is buried in the ground and connected to the protected section.

To protect the internal surfaces of pipelines and their components, internal anti-corrosion pipe coatings based on high-viscosity polymer components are used. It should be noted that pipes with internal polymer coating are highly resistant to moisture and salt deposits. Polymer coatings do not bubble even at sudden pressure changes in the pipeline.

The advantages of polymer coating method sanation over pipeline relaying are as follows:

– in conditions of dense urban development the possibility of wide application;

– intersection with existing communications only in places where technical excavations are opened;

– reduction of the cost of works;

– reduction of the timeframe for the works;

– reduction of the amount of works on improvement of the adjacent territory.

Internal cement-polymer coating is an environmentally friendly, absolutely safe anti-corrosion coating for drinking and industrial underground and surface water pipelines and heating networks.

Cement-polymer composition is a two-composite material consisting of: dry and liquid parts. The dry part is a mixture of hydraulic binder, fractionated sand, and special mineral and chemical additives - modifiers.

The second liquid part of the cement-polymer mixture consists of a rationally selected, thoroughly mixed in factory conditions mixture of mineral-polymer additives of polyfunctional action, this part improves technological (time of mobility retention, workability, delamination characteristics, etc.), physical and mechanical (compressive and tensile strength: water resistance, bond strength, etc.) and corrosion-chemical characteristics of the working solution of the cement-polymer composition.

According to the claimed characteristics in a humid atmosphere the material is stable up to temperature +150°C, working pressure over 0.07 MPa and up to 1.6 MPa inclusive [3]. The main characteristics of the cement-polymer composition are:

– does not affect the operation of equipment and chemical composition of the heat carrier;

– resistant to temperature deformations;

– does not wash out, does not dissolve;

– prevents reduction of pipeline capacity.

An important difference of the technology of pipeline sanation with cement-polymer mixture is that the material:

– under the influence of temperature fluctuations of the heat carrier the material does not crack;

– the material does not wash out or dissolve during its service life;

– does not affect the operation of heat-exchange, boiler, pumping equipment and chemical composition of the coolant;

After sanitation the pipeline gets new operational characteristics:

– formation of deposits and corrosion on the internal surface of the pipe is eliminated;

– hydraulic characteristics of the pipeline are restored;

– no impact on the quality of transported water;

– the service life of the existing pipeline is increased.

The main conclusions on the use of electrochemical protection are: in corrosion-hazardous zones it is necessary to put into operation electrochemical protection after construction or reconstruction of the section of heating networks, thus, to protect the metal of heat pipelines from corrosion processes as soon as possible after installation works. On sections of heat pipelines electrically poorly insulated from the ground (destruction of thermal insulation, contact of metal with concrete structures, etc.), the installations of electrochemical protection are not very effective, because the created protective current is not distributed over long distances along the pipes, but flows into the ground in the places of abutment, which leads to a significant increase in the rate of corrosion processes.

The main negative factor affecting the safe operation of heat network pipelines is corrosion processes on the metal. At operation in conditions of dense building and application in winter time of various chemically active means of struggle against ice and snow that entails change of chemical composition of soils, the task on application of means of electrochemical protection of pipelines becomes more actual. Also, when studying the issue of increasing the percentage of in-pipe corrosion over the last decade, we can say that this increase occurs not because of poor-quality water treatment, but because of the introduction of new pipelines and quite extensive work on the reconstruction of obsolete and outdated pipelines of heating networks.

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