Sealing Properties Study of Sewage Facilities

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Abstract — Results of a study of the leak integrity of industrial reinforced-concrete waste-treatment facilities are presented. The main causes of their permeability are discussed and recommendations for increasing their service life are given.

Key words: liquid rubber mixtures, sealing of reinforced-concrete bodies of waste-treatment facilities, biological treatment of sewage water.

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The decontamination and neutralization of acid and alkaline industrial effluents that are discharged into a general sewage system and outdoor water basins are carried out in special waste-treatment facilities. The inadequate efficiency of the operation of waste-treatment facilities leads to the contamination of rivers and lakes and causes intense corrosion and the premature failure of the equipment and building structures of both decontaminating systems and objects of production work. The main methods for treating sewage water are its physicochemical and biological treatment in the presence of organic substances. Sewage water is often delivered for biological treatment together with domestic sewage or industrial effluents that are easily oxidized biochemically. The majority of equipment used in these cases (industrial tanks, mixers, balancing reservoirs, settling ponds, neutralizing tanks, and pump basins) are made of reinforced concrete. The main causes of the early fracture and premature failure of this equipment are leakages of both the internal anticorrosive coating of a facility and its building. The operating practice of waste-treatment facilities showed that the causes of these defects may be errors introduced in their design and manufacture. In the design, as a rule, the specific features of equipment whose inner surface is subject to corrosion protection are not taken into account. Basic designs often provide for the use of conventional concrete without selecting the water-to-cement ratio, grade of concrete, or an analysis of its crack resistance. These factors are of particular significance for protecting equipment with film coatings and linings without a compensatory elastic underlayer. The studies carried out at the Research Institute of Reinforced Concrete and Concrete (NIIZhB) showed that anticorrosive coatings, including those formed by glass-reinforced plastics (based on perchlorovinyl, epoxy, and other resins) are susceptible to severe cracking with an opening width of cracks in concrete of more than 0.02–0.05 mm. This inevitably leads to the penetration of an aggressive environment into concrete, its corrosion failure, and the loss of the leak integrity in buildings. The examination of a number of failed reinforced-concrete waste-treatment facilities showed that the concrete of their bodies has cracks with a length of 3–15 cm and a depth of 1–2 cm. In some places of the bodies, through-the-thickness leaks were found. The crack formation is attributed to the effect of temperature differences and mechanical stresses on the concrete.

The most efficient method for protecting equipment and building structures from the impact of corrosive wastewater is the covering of their surface with anticorrosive compositions the choice of which depends on the chemical composition of industrial effluents, their temperature, the presence of abrasive inclusions, the design of waste-treatment facilities, and other factors specific to each individual case.

In the 1960s, the Giprokauchuk Institute developed a new method for the biological purification of sewage water with pH 2–3.5 from sulfur compounds. In connection with this, a demand arose for the anticorrosive protection of two aerotanks intended for treatment of the thiocol-production sewage water containing sodium sulfate, sulfuric acid, magnesium sulfate, and polythionates. In the capacity of a 2-mm-thick protective coating, an epoxy-resin based composition was used. After five months of operation, cracking of the coating was found in some places. The defects were eliminated by clearing the damaged areas and applying a composition similar to the basic coating. The aerotanks remained in use for 7 months (until a scheduled repair).

One of the causes of the failure of Dorr settling ponds (diameter up to 30 m) in some enterprises was crack formation under the acid-proof brick lining in
the underlayer of a fiberglass-reinforced epoxy composition. The examination revealed that the cause of the leakage in the protective coating was cracking of the surface layer of concrete as a result of the temperature difference in winter (the temperature of sewage waters delivered to a Dorr settling pond was 70–80°C). Hence, to solve the problem of crack resistance, a crack-opening analysis of concrete must be made in the design of reinforced-concrete bodies of loading facilities with subsequent account for obtained results in selecting protective coating. In the calculation of large-sized equipment, temperature deformation of bodies and coatings must be taken into account. In addition to regard for data on the crack resistance of concrete, it is necessary to provide for the use of crack-proof coatings of liquid rubber mixtures, i.e., thiocol U-30M, Nairit NT, etc. These materials can be successfully used both as an independent coating and an elastic underlayer. In addition to the crack resistance, the density of concrete must be considered in the design; prior to applying a protective coating, it is necessary to test the equipment with filling water. Until now, the problem of testing reinforced-concrete loading facilities has not been given sufficient attention, despite the fact that hydraulic testing yields an objective description of the quality of reinforced concrete. Therefore, in the design, it is necessary to specify the test conditions. For underground reinforced-concrete equipment, the possibility of testing it without pulling down the bodies must be stipulated; in some cases, a complex must comprise a special drainage system placed below the bottom of the device. To construct reinforced-concrete tanks buried in the ground, it is necessary to determine the maximum level of ground water. Cases are known when ground water seeps through concrete and destroys the lining. Taking this into account, when constructing reinforced-concrete tanks of this type, prior to burying them, it is necessary to protect their external surfaces with a waterproof coating or to create a bitumen-clay retainer. Operating experience showed that it is efficient to design nonburied equipment that enables one continuously monitor the state of its external surface and eliminates the occurrence of failures at waste-treatment facilities and neighboring building bases due to the acidification of the ground.

The shape of the body of equipment and its separate units is of great significance. In terms of the static stability of a lining, the shape of a vertical cylinder is the most appropriate. However, most of constructed reservoirs are rectangular in shape; therefore, to enhance the static stability of a lining in an aggressive environment, it is necessary to considerably increase its thickness in the design, which increases the consumption of materials and decreases the reaction capacity of a device. In the case when the technological conditions for using a device require it to have a rectangular shape in the horizontal plane, the inclination of the internal walls in the direction of their dissociation must be stipulated.

When designing chokes, access panels, overflow launders, and interface nodes of the components of a body (both reinforced-concrete and metal), it is necessary to based the design on creating the most effective anticorrosive protection in them. The operating experience of reinforced-concrete Dorr thickeners showed that leakages most often occur at the interfacial sites of the bottom of an overflow launder with the wall of a device and overflow chokes in the launder and the given outlet. In many cases, the design of a launder specified in basic designs does not allow for adequate consolidation of concrete; hence, a more appropriate design is an outside tray. The OAO Montazhkhimzashchita proposed the design of a launder which is a separately prepared independent component installed on a hanging step lining. Depending on the conditions of service, the launder can be prepared of stainless steel, vinyl plastic, or carbon steel protected with chemically resistant coatings (rubber or polymer materials reinforced with various chemically resistant fabrics). To enhance the tightness of the junctions of chokes, outlet pipelines, and other components with the main body of a device, it is recommended to glue (using polymer resins) tapes made from cotton fabric or fiberglass with a width of 400–500 mm on the concrete surface prior to applying the basic coating. All metal strokes must have rings welded to the external surface that are installed at the same time as the choke in the course of concreting the device and serve as stabilizers. The welding areas of the rings must be tested for leaks to prevent a corrosive solution from penetrating the concrete while maintaining the leak tightness of the lining. It is known that, outside of Russia (United States, Germany), stainless-steel overflow pipes intended to withdraw a corrosive solution that penetrated the lining are installed in the body of a device during its concreting. Similarly, it is possible to install sensors whose operating components are wire inlets placed under the lining. The penetration of a solution under the lining drastically varies the potential difference, which is periodically measured on the outside of a device. However, the use of overflow pipes and potentiometers is not always possible because there is a probability of breaking the leak integrity of concrete during installation. In addition, these pipes only enable one to determine the presence of an aggressive medium in concrete without specifying the place of its penetration of the lining.

One of the conditions for the reliable operation of waste-treatment facilities is the correct choice of protective coating. Taking into account these data, as well as domestic and foreign operating experience of protective coatings of waste-treatment facilities, we can recommend the use of an armored lining with an insulating underlayer based on polymer materials. For an armored lining, along with conventional acid-resistant and diabase tile, it is appropriate to use shaped objects...