STUDY OF THE INFLUENCE OF INHIBITORS ON THE PHYSICOCHEMICAL AND MECHANICAL PROPERTIES OF EPOXY COATINGS EP-750

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ABSTRACT

The article, using electrochemical research methods, shows the effectiveness of increasing the service life of EP-750 enamel with the use of organic compounds to protect metals from corrosion in a humid atmosphere containing H_2S, NO_2, CO_2, SO_2.

Keywords: organic compounds, nitrobenzene, captax, aldehyde, chemical compounds, nitrogen oxide, carbon monoxide, sulfur oxide, nitric acid, sulfurous acid, corrosion inhibitor, metal protection, protective effect, corrosion rate, electrode potential, standard electrode, silver chloride electrode, electrode potential, layer thickness.

INTRODUCTION

In the chemical industry, metal structures are often corroded by substances such as H_2S, SO_2, NO_2, CO_2, and acid vapors H_2SO_4, HCl, and others. An effective method of protecting metal structures and equipment from corrosion is the use of paint and varnish coatings. Sometimes these coatings do not effectively protect metal structures from corrosion due to an increase in the concentration of chemicals in the atmosphere, which leads to cracking of the steel, as a result of which emergency emergencies can occur, the results of which can be unpredictable.

To extend the life of the coatings, they are regularly renewed with paint and varnish coatings on the metal surface. The annual application of coatings on the surfaces of structures and equipment presents certain difficulties - cleaning the metal surface, applying several layers of coatings by drying each layer for 1 hour, etc. An effective way to extend the service life of paints and varnishes is the use of inhibited paint coatings. This paper presents a study of the effect of EP-750 inhibited epoxy coating on the protective properties of metal structures and equipment of drilling rigs.

We have previously studied the protective properties of EP-750 epoxy coatings in an atmosphere containing H_2S, NO_2, CO_2, SO_2[1-3].

In this regard, the purpose of this work is: 1) To study the effect of inhibitors on the physicochemical properties of EP-750 enamel in the studied environments; 2) Study of the manufacturability and mechanism of action of the developed inhibitors by determining their diffusion through the coating on steel, the effect on the kinetics of electrode processes.

The study of the effect of inhibitors on the physicochemical and mechanical properties of EP-750 enamel was carried out according to the method described in TU and GOST [4-6]. Nitrobenzene and captax were used as inhibiting additives. Nitrobenzene and captax were added to the EP-750 enamel in an amount of 1.0 wt. %. Samples covered with inhibited and not inhibited EP-750 enamel were placed in a special vessel and the physicochemical and mechanical properties of the coatings were determined.

Conditional viscosity of coatings, which is based on free flow, was determined from the time of continuous flow in seconds of a certain volume of the test material through a calibrated nozzle of a VZ-246 viscometer.

A sample of the test material, selected following GOST 9980-20, was thoroughly mixed before determining the relative viscosity, avoiding the formation of air bubbles in it, while the test paint material should be homogeneous. To eliminate foreign substances, the sample was mixed, filtered through a sieve, and thoroughly mixed again immediately before measurement. At least two parallel determinations were carried out simultaneously. The test was carried out at an air temperature of (20 ± 2) °C. The viscometer and the test material were brought to a temperature of (20 ± 0.5) °C immediately before the test. Before the test, the viscometer and, especially the nozzle, are thoroughly cleaned with a solvent. Fill the viscometer with a sample so that no air bubbles form. The excess material and the formed air bubbles were removed using a glass plate shifted along the upper edge of the funnel in a horizontal direction so that no air layer was formed. The nozzle opening is opened and simultaneously with the appearance of the test material from the nozzle, a stopwatch is turned on. At the moment of the first interruption of the jet of the test material, the stopwatch is stopped and the expiration time is counted. The test was carried out three times and the arithmetic mean was taken. The conditional viscosity (X) is calculated by the formula:

$$X = t \cdot K,$$

Where: t - the arithmetic mean of the expiration time of the test material, c;

K - correction factor of the viscometer.

The determination of the mass fraction of volatile and non-volatile, solid and film-forming substances was carried out as follows: before weighing, cups pre-wiped with acetone were kept in a drying cabinet at the test temperature for at least 10 minutes. After that, the cups were placed in a desiccator, cooled to room temperature, and weighed. Then the test material, thoroughly mixed to a homogeneous consistency, was placed in cups and weighed. To avoid the loss of volatile substances, the cups were covered with a watch glass during weighing. After weighing, the cups are opened and, rotating them, the contents are distributed in a thin layer over the entire surface of the bottom, after which they are placed in a drying cabinet in a horizontal position and heated. After heating, they are transferred to a desiccator, cooled to room temperature, and weighed. If the heating is carried out to a constant mass, then the first weighing is carried out after 30 minutes, and then every 30 minutes. The discrepancy between the results of the last two weighings should not exceed 0.01 g. The mass fraction of volatile (X) and non-volatile (X_1) substances as a percentage is calculated by the formulas: $X = ((m_1 - m_2)/m_1) \cdot 100$ (1) $X_1 = (m_2/m_1) \cdot 100$ (2) where: m_1 - a mass of the test material before heating, g; m_2 - a mass of the test material after heating, g. The arithmetic mean of the results of parallel determinations is taken as the test result, the discrepancy between which should not exceed 1%.

To determine the degree of dilution of the enamel, 120g of the tested enamel was weighed, diluted with a solvent to a working viscosity of 28÷30 according to a VZ-246 type viscometer with a nozzle diameter of 4 mm at a temperature of (20 ± 0.5) °C. The degree of dilution (X) as a percentage was calculated by the formula:

$$X = (m_1 \cdot 100)/m,$$

where m_1 – the mass of solvent used to dilute the enamel, g;m – the weight of enamel, g.

The drying time and degree were determined by the method described in [3]. The degree of drying characterizes the condition of the surface of the paint and varnish material applied to the plate at a certain drying time and temperature. Drying time is a period during which a certain degree of drying is achieved at a given thickness of the paint layer and under certain drying conditions. The drying time and degree were determined at (20±2) °C and relative humidity (65±5)% on three samples at a distance of at least 20 mm from the edge of the sample after natural or hot drying of the applied layer of paint and varnish material. Plates with a layer of natural drying paint and varnish material were kept in a horizontal position in a room protected from dust, draft, and direct sunlight at (20 ±2) °C and relative humidity (65 ± 5)%, during the time specified in the normative and technical documentation for the tested material, and then the test was carried out. When testing, a piece of paper is placed on the painted plate with clean hands or tweezers, taking it by one of the free corners. A rubber plate is placed on a piece of paper, a weight of 20 g is placed in the middle of it; after (60 ± 2) and the weight and the rubber plate are removed, and the painted plate with a piece of paper is freely thrown from a height of 28 ... 32 mm onto a wooden surface. If at the same time a piece of paper does not stick to the film, then the degree of drying has been achieved. The drying time is calculated as the arithmetic means of three parallel definitions, the permissible discrepancies between which do not exceed + 15%.

The elasticity of the film during bending was determined by the method described in [4]. The method consists in determining the minimum diameter of a metal cylindrical rod, the bending on which the painted metal plate does not cause mechanical destruction or peeling of a single-layer or multi-layer paint film. The elasticity of the film during bending on a metal rod is evaluated after testing three plates on the same rod.

The impact strength of the film was determined by the method described in [3]. The method is based on determining the maximum height, when falling from which a load of a certain mass does not cause visible mechanical damage on the surface of the plate with a paint coating. The tested paint and varnish material was applied to the plate following GOST 8832-76. Before testing, the samples are kept at (20 ±2) °C and relative humidity (65 ± 5)% for 48 hours. Carrying out the test: the test is carried out at (20 ±2) °C and relative humidity (65 ± 5)%. The plate is placed on the anvil under the firing pin with the coating down (reverse impact), making sure that it fits snugly to the surface of the anvil. The section of the plate on which the load will fall was installed at a distance of at least 20 mm from the edge of the plate and at least 40 mm from the center of other areas that had previously been hit. The maximum height value is taken as the test result, at which three positive test definitions are obtained.

The adhesion of the paintwork of the lattice incisions was carried out by visual assessment of the condition of the coating according to a four-point system. Two samples were prepared for the test. The test was carried out on two samples and at least three surface areas of each sample. On each test area of the sample surface at a distance from the edge of at least 10 mm, at least six parallel incisions were made with a cutting tool along a ruler to metal at least 20 mm long at a distance of 1, 2 or 3 mm from each other. Similarly, incisions were made in the perpendicular direction. As a result, a grid of squares of the same size is formed on the coating. The distance between adjacent grids should be at least 20 mm. On coatings with a thickness of fewer than 60 microns, a lattice with a single square of 1x1 mm was applied, on coatings with a thickness of 60 to 120 microns - 2x2 mm, on coatings with a thickness of 120 to 200 microns - 3x3 mm. The control of the cut-through coating to the metal was carried out using a magnifying glass. The test results of the inhibited and non-inhibited EP-750 coating are shown in Table 1.

Table 1 Physico-chemical, mechanical and technical characteristics of inhibited and non-inhibited enamel EP-750

The name of the indicator		The norm according to TU 2312-216-00209711-2007	
		EP-750 without inhibitor	EP-750 with captax
Appearance		homogeneous matte surface without foreign inclusions	homogeneous matte surface without foreign inclusions
Mass fraction of non-volatile substances, % (depending on color)		37-45	37-45
Conditional viscosity according to the viscometer VZ-246(4), c.		60-110	60-105
Drying time to degree 3 at a temperature of (20 ± 2) ° C, h, no more		3	3
Shelf life (when mixed with a hardener), h, at least (in a tightly closed container)		72	72
Adhesion, point, no more		1	0,8
The elasticity of the film during bending, mm, no more		1	0,9
The strength of the film upon impact on the device U-1A, cm		50	50
The hardness of the film according to the pendulum device TML 2124, rel, units, not less		0,3	0,32
Resistance at temperature (20±2) °C to static impact, h, not less	water -	72	72
	mineral oil -	24	25
	Gasoline -	24	25
	3% sodium chloride solution	24	30
Degree of grinding, microns		18	20
The hiding power of the dried film, g/m^2		243	249
Drying time to degree 3, hour		20	11
Film color		gray	gray

As can be seen from Table 1, the introduction of an inhibitor into the coating composition has almost no effect on the basic physicochemical and mechanical properties of coatings, and in some cases even slightly exceed the values of indicators than without an inhibitor, which contributes to an increase in the service life of EP-750 epoxy coatings in the studied media.

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