

# Anticorrosion Protection as a Factor in Improving Industrial Safety at Mining Enterprises

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**Abstract.** The issue of reliable and safe operation of equipment, the use of technical devices and materials, the repair and renewal of fixed production assets is relevant. Corrosion processes have a very negative impact on the technical condition and safe operation of equipment, buildings and structures. The reasons for the increasing damage to the fixed production assets are their physical wear, poor quality of rolled stock, reinforced concrete and polymers, non-compliance with processing technology, neglect of the requirements of technical and regulatory documentation. The measures of increasing the service life of fixed production assets through the use of polymer-silicate protective coatings are proposed in this paper. As a result of studying the compositions with various contents of water-repellent and plasticizing additives, it was found that if the content of each of them is 3%, the duration of setting of the polymeric silicate coating increases 1.5 times. At the same time, mechanical strength and setting time remain the same. Also, an increase in the setting time is ensured by the prolonged high-speed mixing of the polymer-silicate mixture.

## 1 Introduction

The Industrial Supervision Authority attaches great importance to the issues of reliable and safe operation of equipment, the use of technical devices and materials, regulation, technical diagnostics, repair and updating of fixed production assets. The urgency of ensuring the safe operation of equipment is due to the fact that, in general, the safe operation of production depends on it. The number of accidents and failures in key industries continues to remain high, and the level of industrial injuries, including fatal ones, is high.

- unsatisfactory technical condition and wear of equipment;
- unsatisfactory state of process discipline;
- poor organization and conduct of installation, repair, gas hazardous and hot work.

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When ensuring the safety requirements, it is necessary to take into account that the fixed production assets of the Russian Federation are substantially overage today, among other reasons due to corrosion.

Corrosion processes have a very negative impact on technical condition and safe operation of equipment, buildings and structures. The reasons for the increasing processes of corrosive damage to fixed production assets are their physical wear, poor quality of rolled metal, reinforced concrete, polymers, non-compliance with processing technology, and neglect of the requirements of technical and regulatory documentation.

The purpose of this work was to develop a method of protection against corrosion as a factor in improving industrial safety.

## 2 Materials and Methods

Since there are many types of corrosion, the priority to combat it is, first of all, to determine the "dominant" factor affecting corrosion failure. Corrosion behavior is conditioned by the environment and is a time-dependent process. Since corrosion is characterized by ambiguity of its hot spot location and origin, determining the causes and patterns of corrosion failures becomes especially important for identifying areas of increased corrosivity and reduced corrosion resistance of the construction material in cases where the surface sizes of technical devices are huge and the hot spot identification is very difficult. The use of statistics and probability theory in this case does not guarantee reliable results. Therefore, to prevent corrosion, it is necessary, first of all, to monitor the compliance to the process technology.

The problem of identifying the causes and patterns of corrosion failures is solved by methods and means of laboratory and industrial control:

- chemical and analytical control of process environment to identify potential corrosive agents;
- laboratory and industrial control of the corrosive state of an object's material by means of witness samples;
- visual measuring control of the actual state of an object, including direct measurements and calculations of the corrosion rate in the "dominant" defect of the greatest corrosive wear.

Corrosion control using witness samples for many years is the only available way to determine the resistance corrosion of material. Samples of any material (metallic and non-metallic) can be placed and tested in a corrosive environment, both in laboratory and in industrial environments. These samples record the influence of the environment on them at locations where they were placed.

In addition to general corrosion, some of the local corrosion types, the surface crack formation, and other types of physical changes of metal can be assessed and tested with the help of samples.

Samples can be placed at almost any point where corrosion can attack. However, it is very important to place them as close as possible to the place where measurements are required. In addition, since it is usually impossible to obtain samples of absolutely identical composition for corrosion tests, in this case a compromise is necessary and it is important that the samples-based corrosion control program takes into account these differences.

The ways to ensure a given durability of production assets under the action of corrosion environment are divided into two groups:

- using corrosion-resistant structural materials;
- applying various coatings to the surface.

The second way to increase durability is considered in the article, since the replacement of all overage production assets of mining enterprises is not possible due to high economic costs.

### 3 Basic results

Reliable operation of any protective coating is, first of all, impermeability, chemical resistance, strength characteristics, which largely depends on the technology of production of the material and the coating. Polymer silicates have these qualities.

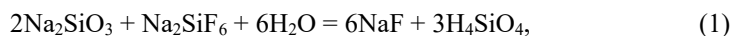
Their use sets the tasks of finding new more effective compositions and modified compounds, taking into account the specifics of the application and the formation of thin-layer coatings.

Modifying additives can be varied both in nature and in the mechanism of their impact on the components of fixed production assets:

- densifying or dispersing (furan, phenolic or other resins);
- water binding (NCO compounds and others);
- reducing shrinkage (oligoesters);
- slowing down setting (sulfanol, silicone fluids);
- plasticizing, etc.

To produce a complex effect, modifiers can be added independently or in various combinations. The problem of producing waterproof coatings was solved by adding solutions of alkali silicates [1-8].

The process of setting silicate materials can be described using the following chemical reaction, in which an orthosilicic acid gel is formed:

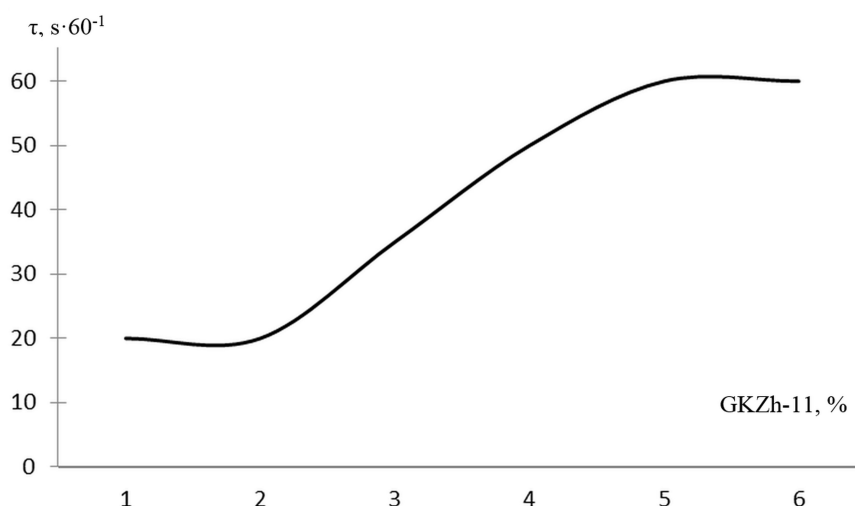


Increasing its resistance to aggressive alkaline media depends on the  $\text{Na}_2\text{SiO}_3$  properties and the amount of  $\text{Na}_2\text{SiF}_6$  as a set accelerator.

One of the ways to increase water and alkali resistance is to increase the content of silicon (IV) oxide in liquid glass. However, at the same time its strength characteristics deteriorate, therefore, an increase in the silicon content must be ensured by admixing silicon-containing additives.

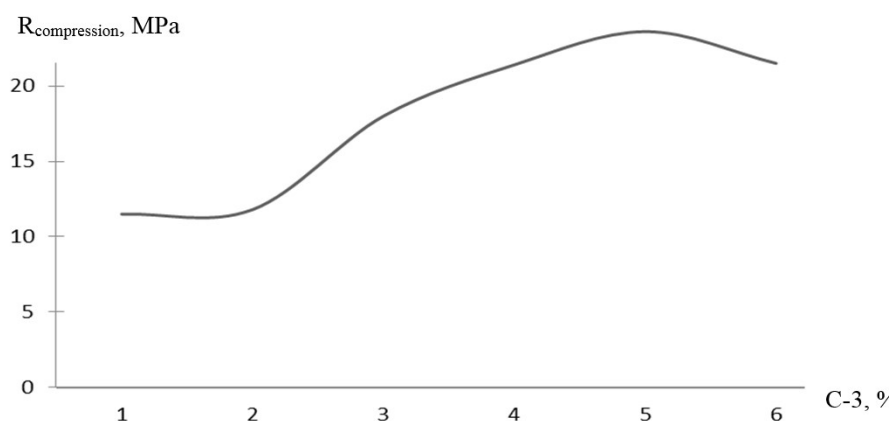
Sodium alkyl silicates containing silicon-oxygen chains contribute to hydrophobization and increase the durability of mixtures. Isocyanic esters reacting with water to form a polyurethane polymer structure also contribute to improve the properties [9-15].

When studying compounds with various contents of hydrophobic additive GKZh-11 (gas condensate liquid), which is a 15% water-alcohol solution of sodium methylsiliconate, it was found that when its content is 3%, the setting time increases 1.5 times (Fig. 1).



**Fig. 1.** The effect of GKZh-11 additive on the setting time of polymer silicates.

However, a decrease in the value of mechanical strength by 1.5 times was also revealed.



**Fig. 2.** The effect of the C-3 additive on the setting time of polymer silicates; air-entraining additive content being constant.

Super plasticizer C-3 (it was added to maintain strength) was used as the studied plasticizer; GKZh-11 content being constant. It can be seen from the graph (Fig. 2) that the optimal amount of plasticizing agent is 3% by weight of sodium silicate, which ensures that the strength remains at the proper level, and what is very important, the achieved value of the setting time does not change.

The mixture containing the determined amounts of additives was subjected to prolonged mixing at high speed, during which it was revealed that it ensures that the required setting time of the polymer silicate mixture under investigation is achieved (Table 1).

Using such a process variable as mixing speed under production conditions, it is necessary to achieve the maximum speed with the use of positive mixing devices.

One of the most important variables for the assessment of the resistance of such coatings is its moisture resistance. The water resistance index was determined by mechanical compressive strength of the samples.

**Table 1.** The influence of the mixing speed and duration on the setting time of polymer silicates.

V, $\text{rp}\cdot\text{s}^{-1}\cdot 60^{-1}$	T, $\text{s}^{-1}\cdot 60^{-1}$	$\tau$ , $\text{s}\cdot 60^{-1}$	R <sub>compression</sub> , MPa
30-32	3	60	23.6
300-350	5	90	23.9
600-700	5	100	24.1
600-700	40	150	25.1

As a result, the variables 4-6 times increase the values of the composition setting duration, which allows applying this type of corrosion protection in the field.

**Table 2.** Main indicators of polymer silicates of different compositions.

Indicator	Composition number			
	1	2	3	4
Weight by volume, $\text{kg}/\text{m}^3$	2248	2260	2276	2295
Mobility, mm	16	22	22	26
Permeability, mm/year	fails	3	3	2
Initial compressive strength, $\text{kp}/\text{cm}^2$	250	236	240	251
Compressive strength after exposure to water, $\text{kp}/\text{cm}^2$	fails	219	226	246
Water resistance index	fails	0.92	0.93	0.99

Certain water resistance values of polymeric silicate solutions did not go beyond the standard values and some samples even exceeded this level. The values of the main indicators for polymer silicate coatings after exposure to water are shown in Table 2. The developed composition shows the greatest resistance to moisture.

## 4 Conclusions

In the course of the work, the features of the influence of the polymer silicates properties on the process variables of the coating production were determined. They consist in increasing the duration of setting with an increase in the content of modifying additives under conditions of prolonged mixing at high speed. This allows applying these coatings in the field.

The analysis of the results of the study of water resistance, water and chemical resistance also indicates the positive effect of the determined process variables for coating production on these important indicators of coating durability.

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