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## ВЫБОР ИНГИБИТОРА КОРРОЗИИ С УЧЕТОМ СВОЙСТВ ДОБЫВАЕМОЙ ПЛАСТОВОЙ ЖИДКОСТИ

### SELECTION OF A CORROSION INHIBITOR TAKING INTO ACCOUNT THE PROPERTIES OF THE PRODUCED RESERVOIR FLUID

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**Аннотация.** В статье рассмотрена методика выбора ингибиторов коррозии для объектов нефтегазодобычи с учетом химического состава добываемых жидкостей. Представлена классификация ингибиторов, особенности их взаимодействия с агрессивной средой, а также процесс лабораторного и опытно-промышленного внедрения. Описан подход к оптимизации выбора реагентов на основе корреляционного анализа условий эксплуатации. Результаты испытаний подтверждают эффективность ингибиторов и возможность сокращения сроков внедрения без потери качества защиты оборудования.

**Ключевые слова:** типы ингибиторов коррозии; внедрение ингибитора коррозии на объект; образец свидетеля коррозии; остаточная скорость коррозии; лабораторные испытания химических веществ; опыт защиты нефтегазовых объектов; внедрение ингибитора коррозии.

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**Annotation.** The article deals with the methodology of selection of corrosion inhibitors for oil and gas production facilities taking into account the chemical composition of produced fluids. The classification of inhibitors, peculiarities of their interaction with aggressive medium, as well as the process of laboratory and pilot field implementation are presented. The approach to optimization of reagent selection based on correlation analysis of operating conditions is described. The test results confirm the effectiveness of inhibitors and the possibility of reducing the implementation time without loss of equipment protection quality.

**Keywords:** types of corrosion inhibitors; introduction of a corrosion inhibitor to a facility; corrosion witness sample; residual corrosion rate; laboratory testing of chemicals; experience in protecting oil and gas facilities; introduction of a corrosion inhibitor.

#### Introduction

According to the experience of applying anticorrosion measures at industrial facilities and the results of numerous scientific studies, inhibitor protection, which increases the durability and reliability of equipment without significant intervention in the specific production process, is one of the most effective and technologically simple ways to reduce metal losses from corrosion [1, 2].

Substances known as corrosion inhibitors, when added to an aggressive medium, significantly reduce the rate of corrosion. In many process operations, inhibitors can be used to reduce corrosion rates. However, a common obstacle to the wider application of this method of corrosion protection is the contamination of process products with inhibitory components.

Equipment used in heat exchangers, power plants, water supply systems, as well as in oil and gas transportation and processing, is protected by corrosion inhibitors. Gas inhibitors, acid corrosion inhibitors, subsurface corrosion inhibitors, aqueous and salt corrosion inhibitors and mechanical corrosion inhibitors are classified according to the type of retarded corrosion processes that they prevent.



### **Types of corrosion inhibitors**

Inhibitors are divided into organic and inorganic depending on their composition. They are further subdivided into groups containing nitrogen, oxygen, sulfur, phosphorus, and other elements [3].

Inhibitors are classified as having blocking activity, energetic action, or mixed action depending on the type of effect they produce.

Anodic inhibitors are classified according to their effect on the corrosion process. Anodic reactions in the corrosion process are inhibited by anodic inhibitors. This group includes envelope inhibitors and oxidizing passivator. Chromatones and nitrites are the most widely used passivators. Sodium hydroxide, sodium carbonate and phosphates are anodic inhibitors that form thin films on the metal surface and prevent the metal from passing into solution.

Cathodic inhibitors affect the rate of cathodic reactions in the corrosion process. They include active reducing agents that bind oxygen and reduce its content in the solution, for example, sodium sulfite, hydrazine, protecting substances that reduce the cathode surface due to the formation of films of hard-to-solve compounds. Substances hindering the cathodic reaction of metal corrosion – cations of heavy metals, for example, bismuth and arsenic.

Inhibitors of mixed action slow down both anodic and cathodic reactions of the corrosion process. This group of inhibitors includes polyphosphates, silicates, etc. The effectiveness of inhibitors in conditions of general uniform corrosion is characterized by the degree of protection and is expressed in percent.

The action of the inhibitor can be characterized by the inhibition coefficient, which shows how many times the corrosion rate decreases as a result of the inhibitor action.

Despite a number of differences in the explanation of the mechanism of action of metal corrosion inhibitors, especially of organic origin, the basis determined in all cases is, first of all, their adsorption at the interface «metal – medium».

### **Introduction of corrosion inhibitor to the facility**

Protection of pipelines of oil gathering system starts with monitoring of background corrosion rate on the installations of control of corrosion of well pad pipelines by installing a sample of corrosion witness and exposure to a certain exposure, after which at increased rate of corrosion of metal and reducing the weight of the sample of corrosion «witness» [4, 5].

After that, the oil producing company applies to the laboratory to test a sample of metal exposed to an aggressive environment, after which laboratory conditions are created based on the six-component composition of water extracted as part of hydrocarbon raw materials and the technological process of pumping oil to test the background corrosion rate in accordance with the technological parameters of the plant or the object under study, subsequently a request is sent to authorized organizations that manufacture chemical reagents, to develop a formulation of a corrosion inhibitor based on the test results obtained, the six-component composition of water extracted from hydrocarbon raw materials and the technological process of pumping oil, in order to depersonalize chemical reagents and subsequently test reagents through an objective assessment and selection of inhibitors that have proven effective in laboratory conditions in accordance with the organization's standards on the effectiveness of corrosion inhibitors and the manufacturability of chemical reagents [6].

### **Laboratory testing of the reagent**

The process of laboratory testing implies determination of the minimum effective dosage of a chemical reagent in laboratory conditions with subsequent recommendation during pilot tests. Also, during pilot field tests, it is not excluded the fact – reduction of chemical reagent dosage in order to increase the economic efficiency of this reagent application.

### **Tender purchases**

At the next stage, reagents are purchased in the form of tenders from selected reagents in order to increase the economic efficiency of the shield and reduce liabilities associated with the introduction of new reagents and increase the economic effect of the sale of already used reagents by reducing the purchase price, since the operating costs of oil production directly depend on the cost of-we have purchased a chemical reagent.

After the control purchase, the inhibitors go through the implementation stage at the field through pilot field tests, the work on inhibitory protection should be carried out by the service company and an expert from the organization that produced the corrosion inhibitor to approve the compliance of the inhibition process. After the implementation procedure, meetings are held to approve the corrosion inhibitor and a conclusion on its effectiveness in pilot field tests, after which, the scientific and technical Council, the inhibitor is recommended for industrial use or for use as an alternative inhibitor in subsequent purchases in case of greater economic effect [7].

### **Simplification of corrosion inhibitor introduction on the example of Achimov deposits**

#### **Urengoy oil and gas condensate field**

The method of simplified introduction of corrosion inhibitor consists in analytical selection of chemical reagent by correlation analysis of operated objects and pipeline sections with similar technological parame-



ters. So, on the example of Urengoy oil-gas-condensate field with exploited layers of Achimov deposits the following condition is distinguished: the model of formation water of different Achimov horizons  $N_1$  and  $N_2$  has the difference of mineralization in 8059,4 mg/dm<sup>3</sup>, but at the same time technological parameters of exploitation of these objects have insignificant differences. Salt content and mineralization of formation water are given in table 1.

Table 1

**Six-component composition of formation water model of two different horizons of Achimov deposits [compiled by the authors]**

Name of salts	Content, mg/dm <sup>3</sup>	
	$N_1$	$N_2$
Na <sub>2</sub> SO <sub>4</sub>	154,3	34,5
NaHCO <sub>3</sub>	1142,4	41,7
CaCl <sub>2</sub> · 2H <sub>2</sub> O	603,9	30,2
MgCl <sub>2</sub>	144,4	10,1
NaCl	6791,6	733,5
KCl	679,2	91,0
Total mineralization	9367,9	1308,5

Thus, as part of the introduction of a new chemical reagent, it is possible to «exclude» laboratory testing under the conditions of the  $N_2$  reservoir water model in the case of proven effectiveness of the reagent in a more aggressive environment, the  $N_1$  reservoir water model, with similar technological parameters, which in turn reduces the time from the request to the introduction of the reagent by the time required to conduct tests for the  $N_2$  facility has an economic effect equal to the cost of conducting tests for the corrosion inhibitor, as well as the company's scientific and technical center, Based on the correlation of the data obtained from all fields, it is possible to recommend for industrial use or pilot field testing, neglecting laboratory studies of corrosion inhibitors not previously used at this facility, which will increase the range of alternative chemical reagents and the competitiveness of manufacturers [8].

To confirm this hypothesis, we will analyze the results obtained from a series of laboratory tests of corrosion inhibitors № 1 and № 2 in the reservoir water model  $N_1$  and  $N_2$ . Both tests were carried out using the gravimetric method by determining the residual corrosion rate during constant purging of inert CO<sub>2</sub> gas, which is an oxidizer, and the main difference between these tests is test medium, therefore, test № 1 was carried out in a solution of a reservoir water model, at the same time, for test № 2, a two-phase medium containing a model of reservoir water and a hydrocarbon phase was used. The results of the tests are recorded in table 2.

Table 2

**Residual corrosion rate and protective effect of inhibition according to the results of laboratory tests № 1 and № 2 [compiled by the authors]**

Name of the test	Reservoir water model	Names of the inhibitor	Residual corrosion rate, mm/year	Protective effect of inhibition, %
Test № 1	Ach <sub>1</sub>	inhibitor № 1	0,064	95,5
		inhibitor № 2	0,059	95,9
	Ach <sub>2</sub>	inhibitor № 1	0,048	93,1
		inhibitor № 2	0,040	94,2
Test № 2	Ach <sub>1</sub>	inhibitor № 1	0,066	95,4
		inhibitor № 2	0,064	95,5
	Ach <sub>2</sub>	inhibitor № 1	0,053	92,3
		inhibitor № 2	0,050	92,8

**Conclusions**

The results of laboratory tests showed that the selected inhibitors have proven effectiveness, exerting a protective effect of more than 90 % at a stable corrosion rate of no more than 0,1 mm/year, as well as indicating greater effectiveness in a less aggressive environment, which confirms the hypothesis that the tests performed in a more aggressive environment with similar the technological parameters of operation serve as the basic basis for the introduction and application of chemical reagents at both facilities and allows, with a competent correlation analysis of the facilities, to introduce chemical reagents or recommend them for pilot field tests, neglecting laboratory tests.

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