Statistical methods for monitoring the operation of cathodic protection stations

Tatiana Gerasina[1,*], *Alexey* Zarubin[1], and *Oxana* Zarubina[1]

[1]Tomsk Polytechnic University, Engineering school of natural resources, 30 Lenina avenue, Tomsk, Russia

Abstract. This article is a result of the research on the methods to monitor the operation of cathodic protection stations. This study presents the experimental data analysis of the work of cathodic protection stations was carried out by the transportation company with measurements for two quarters. Statistical analysis realized on the basis of Shewhart control charts.

1 Introduction

According to STO Gazprom 2-3.5-047-2006 cathodic protection system should provide the necessary degree of potential protection. To obtain a certain level of product or service quality, it is required to create a stable production process that has the appropriate ability to sell quality products within the established range. The possibility of achieving the goal relates to management processes. Achieving this state of processes is one of the main management tasks, including quality management.

Exploration of gas complex takes place in various climatic conditions and in soils with different corrosive activity [1]. In this regard, the problem of increasing the efficiency of diagnostics of electrochemical protection is relevant. Statistical methods of information processing are actively used in the analysis and quality control. The use of mathematical processing methods in combination with existing instrumental research methods will allow for more thorough analysis and improvement of electrochemical protection [2].

The purpose of the work is the application of statistical methods to improve the monitoring works of the cathodic protection stations. The work is aimed at identifying changes in the values of the polarization and total potential. In addition, the work is carried out to select the criteria for ensuring and maintaining electrochemical protection at an acceptable and stable level, guaranteeing correspondence with the established requirements.

In this study, the experimental data analysis of the work of cathodic protection stations was carried out by the transportation company with measurements at the beginning and the end of month for two years.

2 Methods and object of study

Production processes are very variable, since the variability of the processes and characteristics of the product can be described mainly in terms of statistics. To process data you need to use computers.

The control limits is determined on the assumption that the process is stable, and therefore the distribution is normal. If the process satisfies the assumptions about stability, then it is considered controlled and is called the "Shewhart process model".

The range defined by the two limits, usually denoted in the literature as:

- UCL – upper control limit;
- LCL – lower control limit;
- CL – central line (average pipeline potential, which is calculated individually for each of the three cases)

Limitation such as UCL and LCL are defined as a multiple of the standard deviation of the normal distribution of probability of the process random variables from the expected value.

Depending on the adopted multiple value, the size of the limitations increases or decreases:

$UCL = \mu \cdot k \cdot \sigma$;

$LCL = \mu \cdot k \cdot \sigma$ [3];

where:

μ – is the expected value of the characteristic in the process;

σ – is the standard deviation of the characteristic in the process;

k – is a constant.

In practical applications, the value of k is usually taken as 3. The values k = 1 and 2 are used as special limits, the so-called alert limits (internal control limits), regardless of the UCL and LCL, which are defined as external. In most control charts, control limits as well as the points on the card concern not only individual measurements but also the mean values of the n-element samples (n = 2 to 10).

Statistical analysis realized on the basis of Shewhart control charts. The Shewhart control chart is a graphical way of presenting information which is based on a sequence of samples reflecting the current state of the

* Corresponding author: Gerasina.t.a@yandex.ru

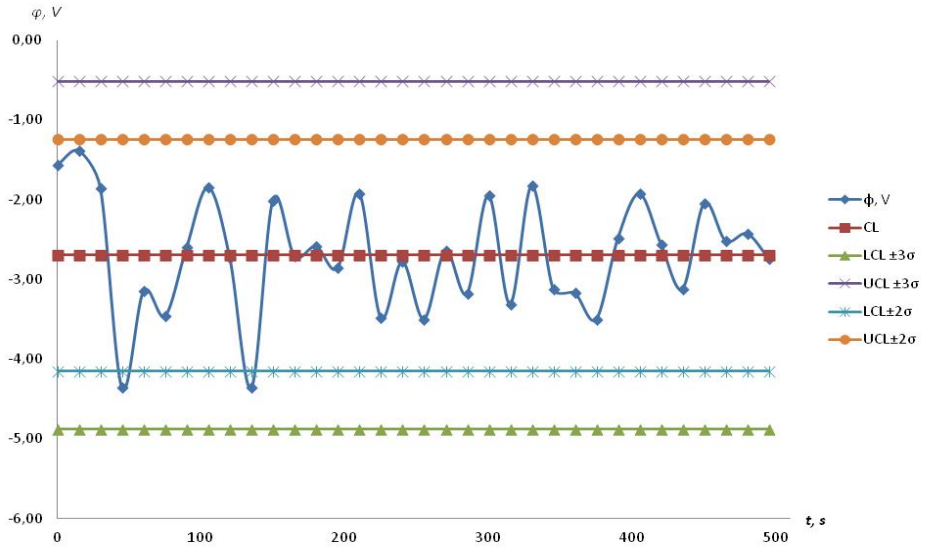

Fig. 1. Shewhart control charts in the operation of the cathodic protection station by total potential in the first quarter

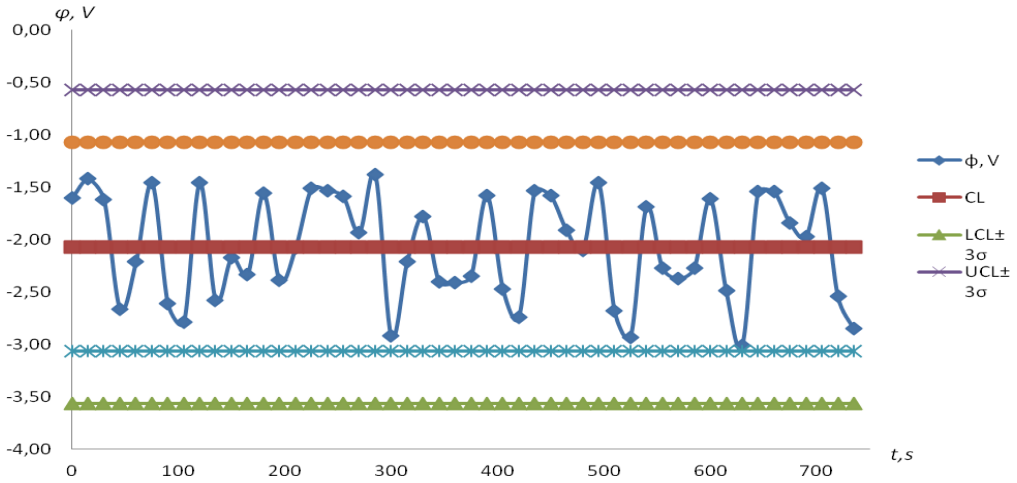

Fig. 2. Shewhart control charts in the operation of the cathodic protection station by total potential in the second quarter

process. Inhibition of corrosion processes occurs on the surface of the pipeline during the operation of electrochemical protection. In this process, the potential is shifted to the negative side more than 100 mV.

Based on this, the polarization potential is the main criterion of security in different environments in the regulatory documents on the electrochemical protection of steel structures [3, 4]. Regulation of the operation mode of an ECP is carried out by the following parameters: by the value of the potential or by the magnitude of the protection current [5].

3 Results and discussion

Shewhart control charts were used as the potential is one of the main parameters for regulation electrochemical protection (fig. 1, fig. 2). The chart shows: warning and action limits on the charts to act as sign when the system is going out of control,

Where *φ, V* – is the pipeline potential using a copper sulfate reference electrode

From the range of experimental data obtained, the most interesting range as exceeding permissible values was selected (Experimental data were recorded every second during the day). Shewhart control charts allow to control the stability of the standard deviation of repeatability. It takes place when the measurements are repeated for the control material.

The control chart method helps determine if a process has actually reached a statistically controlled state. it is necessary to maintain control and high degree of uniformity of the measurement characteristics through information recording during operations. According to the data, Shewhart charts were compiled, which made it possible to determine the process controllability in the limit of warnings and actions.

The second situation is the influence of stray currents on the pipeline section (Fig. 3). The data were obtained under the influence of stray currents on the cathodic protection station, the parameters were recorded within a minute after the train passed. The main features of a statistically unstable state are the deviation from the action limit, when more than four points is at one side

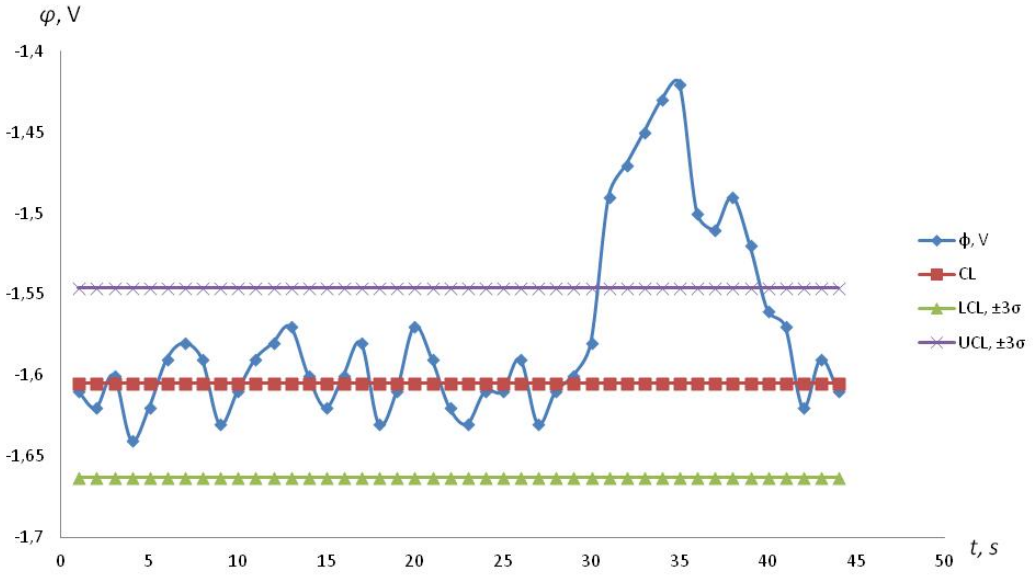

Fig. 3. Shewhart control charts in the operation of the cathodic protection station under the influence of stray currents

from the centreline. Wandering currents occur in the presence of electrified objects. Based on the above, the work of the cathodic protection station is unstable, if determined statistically on the basis of measurements from the sample. It means deregulation of the process stability.

The main issues related to the process control are to determine whether the process is statistically regulated or nor and whether the actual value of the product characteristics is consistent with the normative characteristics.

4 Conclusion

Based on the data obtained, it was possible to get an idea of the full-fledged work that takes place daily at the production sites. It gives a true picture of the capability and performance of the processes and the ability to meet requirements. The model also indicates the statistical causes of the instability and thus directs the operation for process improvement (fig. 3.).

As a result, the real, technological and organizational causes should be the subject of detailed research and analysis. But the widest application of the proposed models is in production processes. With the success, it uses in a wide range in different processes, which are repetitive, giving the opportunity to obtain a random sample of sufficient size in terms of estimation of the statistical parameters of the distributions and compliance verification of the empirical distribution with the theoretical distribution.

Based on the total potential the work of the CPS is stable. Within six month of operation, the value of the total potential was in range of boundary control. The formulated eight rules [6] allow to exclude an unstable state on the control charts. Consequently, the work of the CPS presented in fig. 1 and fig. 2 and presented in a statistically controllable state. In fig. 3 there is unstable stray currents occur. Exceeding by the controlled characteristic (the line UCL or LCL), whose values are

process, where during the repeated tests, the deviation from the working value reappeared under the influence of stray currents.

As a result of this work, statistical methods of monitoring cathodic protection stations were used. In addition, as a working parameter, total potential was used, which gives the most complete information about the work of cathodic protection stations.

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