Optimization of measuring instruments’ composition at the enterprise

M S Ostapenko* and Z A Kalimullina
Tyumen Industrial University, the City of Tyumen, Russia

*ms_ostapenko@mail.ru

Abstract. This article discusses the component of metrological production support of a life-supporting enterprise - the work of monitoring the water pressure in the pipelines of a workshop for operating networks and booster pumping stations. Features of the current system of metrological production support are considered and characteristic shortcomings are revealed. Based on the conducted analysis, the authors propose a solution whose purpose is to optimize the existing set of measuring instruments located in the metrological department of the enterprise, considering an important component - the economic criterion.

1. Introduction
A high level of metrological production support of a life-supporting enterprise is the key to providing high-quality and uninterrupted services for various consumers.

The article discusses an enterprise providing water supply and sanitation services, both for industrial consumers and ordinary residents of apartment buildings and private houses.

2. Characteristics of the current system for metrological production support within the production shop of the enterprise
The article discusses the process of metrological production support of a workshop for the water supply and booster pumping stations operation. In particular, close attention is paid to measuring instruments that monitor the water pressure in pipelines.

The metrological service of the enterprise provides support, uninterrupted monitoring and recording of water pressure (measuring instruments) in pipelines at 96 booster pumping stations of the enterprise. Each station is equipped with at least six water pressure meters. Thus, the number of measuring instruments for 96 booster pumping stations amounts to 596 units. Since water supply and sanitation services are rendered around the clock, emergency and repair crews must immediately respond to the failure of equipment and various devices, as well as take measures to prevent them and reduce the risks of a re-occurrence of various kinds of accidents as a result of malfunctioning equipment [2].

According to the data from 2015 to 2019, it was found that the number of calls of emergency and repair crews to replace broken down devices that monitor water pressure increased twofold with the same number of emergency and repair crews. The dynamics of failures and the number of calls to eliminate or replace water pressure monitoring devices are shown in Figure 1.
As can be seen from the figure, the number of breakdowns of water pressure measuring instruments over the specified period has increased significantly. The increase in the number of calls of emergency and repair teams is due primarily to the fact that every year the number of the production workshop’s booster pumping stations where measuring instruments are operated is growing. For example, as of the beginning of 2015, the workshop oversaw 62 booster pumping stations, and by the end of 2019, 96 such stations were involved. Besides, this failure is also caused by moral and physical deterioration of measuring instruments.

Given the fact that positive dynamics of the city population’s growth directly affect the growth of production facilities and the volume of services provided by the enterprise, the goal was to replace obsolete and worn-out measuring instruments with more modern and modernized ones. The goal was to automate the process of water pressure monitoring in pipelines in the workshop for the water supply and booster pumping stations’ operation. Having studied the market of domestic and foreign representatives engaged in the production of instruments for liquid pressure monitoring in pipelines, it was found that the set goals correspond to intelligent pressure sensors, whose functionality includes the ability to automatically collect and transmit data to the control center of the enterprise [1], [3].

Replacing obsolete measuring instruments with more modern and modernized ones will reduce the number of measuring instruments at each booster pumping station. It is assumed that the number of measuring instruments at each booster pumping station will be reduced from 6 units to 2 due to high accuracy of the measurements, and thereby the calls of emergency and repair teams to eliminate or replace failed measuring instruments will be significantly reduced. Such changes will make it possible to redirect and use production resources of teams for other purposes.

3. Feasibility of the method for optimizing the composition of measuring instruments, considering the economic criterion

In order to prove feasibility of the presented method for optimizing the stock of measuring instruments, we calculated the economic costs of maintaining a working measuring instrument in working condition for 1 calendar year for the existing system and for the proposed method. The calculation of economic costs was carried out according to the following formula:

\[ S_{mi1} = S_{d1} + S_{ld1} + S_{m1} + S_{v1} + S_{r1} \]  

(1)
Where $S_{mi}$ is the amount of economic costs for maintaining in working condition 1 unit of measuring instrument for 1 calendar year, $S_d$ is the cost of the measuring instrument, $S_{id}$ is the cost of mounting/dismounting of the measuring instrument, $S_m$ is maintenance cost of the measuring instrument, $S_r$ is the cost of metrological works (verification/calibration), $S_r$ is the cost of a backup measuring instrument, which is equal to the value of the measuring instrument itself. Thus, to provide 1 unit of measuring instrument at booster pumping stations, the amount of economic costs will approximately be as follows:

$$S_1 = 730.00 + 400.00 + 1547.00 + 240.00 + 730.00 = 3647.00 \text{ rub.}$$

Therefore, the amount of economic costs to provide 576 units of measuring instruments will approximately be the following:

$$S_{576} = 3647.00 \times 576 = 2100672.00 \text{ rub.}$$

Based on the proposed method for reducing working measuring instruments at each booster pumping station (replacing technical manometers with intelligent pressure sensors), the number of working measuring instruments will be reduced by 3 times, i.e. the total number will amount to 192 units of measuring instruments. According to formula 1, we will calculate the economic costs to ensure 1 unit of measuring instrument according to the proposed method for reducing working measuring instruments:

$$S_1 = 2330.00 + 400.00 + 1800.00 + 350.00 + 2330.00 = 7210.00 \text{ rub.}$$

Similarly, we will determine the amount of costs for 192 units of measuring instruments:

$$S_{192} = 7210.00 \times 192 = 1384320.00 \text{ rub.}$$

Based on the presented calculations, we can conclude that the transition to intelligent pressure sensors will reduce the cost of equipping and maintaining in working condition measuring instruments by 1.5 times.

Equipment of the workshop for water supply and booster pumping stations’ operation with intelligent pressure sensors will not only optimize the stock of working measuring instruments of the metrological service of the enterprise, but also make a significant contribution to the improvement of technological processes, automate the process of transmitting the received measuring information to the control room of the enterprise, minimize the time, human and technical resources that the company’s staff uses to eliminate a particular emergency situation, significantly extend the service life of working measuring instruments by using modern types of working instruments, reduce the economic costs of equipping and maintaining working measuring instruments in working condition during operation [4].

References
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