The effectiveness of the introduction of new equipment in the test laboratory center

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Abstract. Improving the quality of the services provided by updating the laboratory base is considered as one of the most important ways to increase competitiveness, achieve competitive advantages, which, in turn, helps to increase the economic efficiency of the testing laboratory center. The introduction of new equipment at the TLC will contribute to an increase in the possible number of studies being carried out, a decrease in random errors, and the achievement of the best indicators of internal laboratory control. The introduction of the PLP-01M microwave laboratory system will significantly reduce the time for preparing a sample for analysis by reducing the decomposition time of the sample by 19.5 times. Upgrading the equipment used from Kvant-AFA to Kvant-2AT with the simultaneous introduction of the PLP-01M microwave laboratory system will not only improve the used measuring instrument, but also the entire sample preparation system as a whole.

1. Introduction

In the conditions of market relations at any enterprise, including testing laboratories, the relevance of quality management is determined by its focus on ensuring such a level of quality of services that can fully satisfy all consumer needs. The high quality of the services provided is the most significant component that determines competitiveness. The lack of updating of measuring instruments, test and auxiliary equipment makes it difficult to ensure a stable quality of services. The processes of updating the laboratory base in modern conditions of the development of scientific and technological progress are objectively necessary.

Improving the quality of services provided by updating the laboratory base is considered as one of the most important ways to increase competitiveness, achieve competitive advantages, which, in turn, contributes to increasing the economic efficiency of the testing laboratory center (hereinafter referred to as the TLC).

The relationship between the introduction of new equipment and the economic efficiency of the ILC is shown in figure 1.
Figure 1. The relationship between the introduction of new equipment and the economic efficiency of the ILC.

Ensuring food safety remains an urgent and priority task [1-7]. Assessment of the quality and safety of the developed food products is a prerequisite [8-18]. In the conditions of market relations at any enterprise, including testing laboratories, the relevance of quality management is determined by its focus on ensuring such a level of quality of services that can fully satisfy all consumer needs. The lack of updating of measuring instruments, test and auxiliary equipment makes it difficult to ensure a stable quality of services. The processes of updating the laboratory base in modern conditions of the development of scientific and technological progress are objectively necessary [19-27].

The research task is to calculate and analyze the economic efficiency of the introduction of new equipment in the laboratory.

2. Materials and methods
Equipment: microwave laboratory system PLP-01M, devices (Kvant-2AT, Kvant-AFA, Kvant-2AT, Kvant-AFA).

Calculation of the research program:
Calculation of the annual balance of working hours for 2020.
Equipment operating time:
\[ T_c = 366 \text{ days} \]

Equipment downtime for major repairs is not provided:
\[ T_{mr} = 0 \text{ days} \]

Total work shifts:
\[ C_{sh} = 1 \]

Duration of shifts:
\[ T_{sh} = 8 \text{ h} \]

For discontinuous measurement processes, the actual operating time of the equipment is calculated by the formula:
\[ T_{fact} = (T_c - T_{sh} - T_w) \times C_{sh} \times T_{sh} \times (1 - T_{cur}/100), \]
Where: $T_w$ – weekends and holidays; $T_{cur}$ – current downtime, in % of the nominal operating time.

Working time fund is the duration of work of one average employee in the reporting period. To determine the effective fund, the working time norm is used, approved for each year by the Ministry of Labor of the Russian Federation.

3. Results and discussions

The cost of introducing new equipment depends on the cost of the equipment, transportation costs, installation and installation costs, and personnel training costs.

The project for the introduction of new equipment is based on the need to update the laboratory base of instruments and replace existing measuring instruments.

It is supposed to choose the optimal set of measuring instruments, based on the volume of analyzed samples, the productivity of the instruments, the payback period of the equipment being introduced, and the solvency of the TLC.

Let's calculate the capital costs for implementation:

- atomic absorption spectrometer "Kvant-2AT";
- analyzer voltammetric "TA-4";
- analyzer "Pan-arsenic";
- atomic absorption spectrometer "Quant-2AT" and microwave laboratory system PLP-01M at the same time;
- microwave laboratory system PLP-01M.

Table 1 shows the data on capital expenditures for the introduction of new equipment.

| Name                                      | Cost, rub. |
|-------------------------------------------|------------|
| **Atomic absorption spectrometer "Kvant-2AT"** |            |
| Cost of equipment                         | 1350000    |
| Staff training costs                      | 20000      |
| Fare                                      | 9500       |
| Installation and assembly costs           | 42000      |
| Total:                                    | 1 421 500  |
| **Voltammetric analyzer "TA-4"**          |            |
| Cost of equipment                         | 111600     |
| programmable two-chamber oven PDP-18M     | 42500      |
| Staff training costs                      | 5500       |
| Fare                                      | 2500       |
| Total:                                    | 162 100    |
| **Analyzer "Pan-As"**                     |            |
| Cost of equipment                         | 63900      |
| programmable two-chamber oven PDP-18M     | 42500      |
| Fare                                      | 2500       |
| Total:                                    | 108 900    |
| **Microwave laboratory system PLP-01M**   |            |
| Cost of equipment                         | 486990     |
| Staff training costs                      | 5500       |
| Fare                                      | 2300       |
| Installation and assembly costs           | 1500       |
| Total:                                    | 496 290    |
The costs for the introduction of new equipment in the TLC will be:

- for the atomic absorption spectrometer "Kvant-2AT" - 1,421,500 rubles;
- for the analyzer voltammetric "TA-4" - 162,100 rubles;
- for the analyzer "Pan-arsenic" - 108,900 rubles;
- for the atomic absorption spectrometer "Kvant-2AT" and the microwave laboratory system PLP-01M at a time - 1,917,790 rubles;
- for the PLP-01M microwave laboratory system - 496,290 rubles.

The current downtime is 17% of the nominal operating time: \( T_{\text{frac}} = 17\% \)

Weekends and holidays: \( T_{\text{w}} = 119 \) days.

The actual operating time of the equipment is:

\[
T_{\text{факт}} = (366 - 0 - 119) \times 1 \times 8 \times (1 - 17/100) = 1640.08 \text{ h} \approx 1640 \text{ h}.
\]

The calculation of the effective fund of working time of laboratory workers for 2020 is presented in table 2.

Table 2. Calculation of the effective fund of working time of laboratory workers.

| №  | Index                                           | Value |
|----|------------------------------------------------|-------|
| 1  | Calendar fund of working time, days            | 366   |
| 2  | Weekends and holidays                          | 119   |
| 3  | Working hours, days                            | 247   |
|    | h                                              | 1976  |
| 4  | Absenteeism, days, including                   | 42    |
| 4.1| regular vacations                              | 28    |
| 4.2| leave for study                                | 12*   |
| 4.3| other losses of working time                   | 2*    |
| 5  | Effective fund of working time, days           | 205   |
|    | h                                              | 1640  |

* – values are given conditionally

Effective working time fund - the duration of the actual work of one employee in the reporting period. An effective fund of working time allows you to calculate the need for personnel according to the complexity of the research program. The performance of the measuring equipment, taking into account the time spent on the sample preparation procedure, the construction of calibration graphs, and the internal laboratory control, is presented in table 3.

Table 3. Performance of measuring equipment.

| Equipment identification                          | Number of studies per year | Duration of sample preparation 1 analysis, h | Number of studies per day |
|--------------------------------------------------|-----------------------------|---------------------------------------------|---------------------------|
| Atomic absorption spectrometer "Kvant-2AT"       | 32 960                      | 23.4                                        | 159                       |
| Voltammetric analyzer "TA-4"                     | 9 694                       | 12.5                                        | 46                        |
| Analyzer "Pan-arsenic"                          | 8 078                       | 13                                          | 38                        |
| Photoelectric concentration colorimeter "KFK-2MP" | 6 463                       | 24.5                                        | 30                        |
The productivity of the outdated model of the atomic absorption spectrophotometer "Kvant-AFA" is 19,388 tests per year, and the currently used KFK-2MP 6,463 tests per year. The annual research volume varies depending on the number of samples, the volume of orders for analysis, seasonal fluctuations.

4. Conclusion
The introduction of new equipment at the ILC will contribute to an increase in the possible number of studies being carried out, a decrease in random errors, and the achievement of the best indicators of internal laboratory control. The introduction of the PLP-01M microwave laboratory system will significantly reduce the time for preparing a sample for analysis by reducing the decomposition time of the sample by 19.5 times.

Upgrading the equipment used from Kvant-AFA to Kvant-2AT with the simultaneous introduction of the PLP-01M microwave laboratory system will not only improve the used measuring instrument, but also the entire sample preparation system as a whole.

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