JUSTIFICATION OF THE LOAD STANDARDS FOR THE IMPLEMENTATION OF TASKS BY THE INSPECTOR COMPOSITION OF EMERGENCY PREVENTION UNITS

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Abstract: The conducted studies are devoted to the method of assessing the number of inspectors, which is based on the balance between the quality of the performance of preventive functions to prevent emergencies and the load standards for the implementation of the corresponding function. Statistical data on fires and the performance of functions by the inspectorate in Ukraine are provided. An analysis of literary sources on the methods of determining the number of employees was carried out, their comparison was conducted; advantages and disadvantages were identified and examples of implementation in practical activities were given. The criterion that should be used when assessing the number of inspectors has been determined. The procedure for substantiating the load standards for the implementation of the functions of the inspectorate is proposed as a basis for the development of methodological recommendations for calculating the required staffing of the inspectorate of prevention units. A list of the main functions of the inspection staff of the prevention units, which are assigned to them by the relevant normative documents, has been established. The dependence of the labor costs required for supervision of one economic object depending on the total number of economic entities was established. A mathematical method was selected and implemented for processing the received statistical data on labor costs, which are used by territorial units during the implementation of the corresponding function. Load standards (labor costs) have been established for the implementation of the relevant functions of the inspectorate of emergency prevention units. Methodological recommendations for determining load standards and calculating the required number of inspectors of emergency prevention units have been developed.

Keywords: load standards; inspection staff; units for the prevention of emergency situations; required staffing; prevention.

1 Introduction

There are many approaches and methods for optimizing organizational staffing structures and the number of workers in organizations [1, 3, 4, 9, 13], among them there are normative (methods of technical standardization), analytical (methods of analytical research), experimental and statistical, the method of correlation-regression analysis, and others. For example, the normative method provides for the calculation of the total number of employees based on certain criteria that are laid down in normative legal acts. In our case, such criteria can be indicators of the inspectors' activity, such as the number of objects to be inspected during the planned period, etc. [18].

The analytical method is based on periodic evaluation of production indicators and economic costs with further conclusions regarding the quantitative composition of employees, which are based exclusively on economic criteria. The basis of the research-statistical method is the assessment of production indicators in comparison with a certain period, which is implemented with the help of statistical data. The method of correlation-regression analysis establishes the dependence of the number of employees on such factors as wages, business trips, the need to involve third-party organizations, etc.

The general drawback of the above-mentioned methods is that they do not take into account such an indicator as the load standard, the performance of a certain function, which, in our opinion, should be the basis of the method of determining the number of inspectors. Since, on the one hand, an unreasonably understaffed number will lead to low-quality performance of emergency prevention functions, which in turn will lead to an increase in the number and scale of emergency situations; on the other hand, an excessive number of personnel will lead to unreasonable economic costs.

Therefore, the approach based on the balance between the quality performance of emergency prevention functions and load standards during the assessment of the number of inspectors needs scientific justification.

According to statistical data in Ukraine [2], the number of fires has almost doubled over the previous decade; 1,853 people died as a result of the fires, including 35 children; 1,383 people were injured, including 90 children. Material losses from fires amounted to 13 billion 363 million 545 thousand UAH (of which direct losses amount to 3 billion 181 million 197 thousand UAH; indirect losses - 10 billion 182 million 348 thousand UAH).

The main data characterizing the situation of fires in the state are presented in Figure 1.

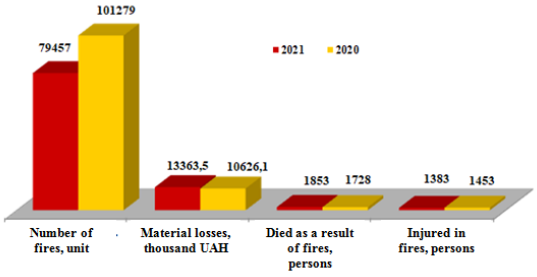

Figure 1. The main indicators characterizing the situation of fires in the state in 2021 compared to 2020

It should also be noted that on the territory of Ukraine, 109 thousand 938 objects with high, 123 thousand 206 objects with medium, and 226 thousand 883 objects with insignificant level of risk, as well as 35 thousand 372 objects of government bodies are registered in the state supervision (control) bodies in the field of man-made and fire safety objects. According to statistical data, every year state supervision bodies in the field of man-made and fire safety conduct about 100,000 planned and unplanned inspections of the objects of government bodies and business entities, as a result of which about 1 million measures are proposed and about 50,000 administrative protocols are drawn up. Data on the number of objects serviced by the inspection staff are shown in Figure 2.

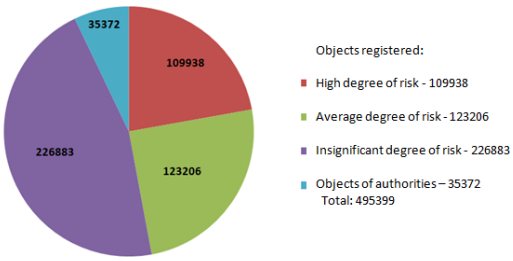

Figure 2. The number of objects in Ukraine serviced by the inspection staff

Thus, the substantiation of load standards (labor costs) for the implementation of the corresponding function of the inspection staff of emergency prevention units, as a scientific basis for the development of methodological recommendations for determining the load standards and calculating the required

number of inspectors of emergency prevention units is an urgent scientific and technical task.

2 Materials and Methods

Today, the basis of the methodology [19], which is used to determine the required number of inspectors of emergency prevention units, is based on the ratio of the annual amount of working time required for the performance of functional duties to the useful annual fund of working time of this employee. A differentiated approach to determining the required number of employees is ensured by the introduction of correction coefficients and it takes into account only the quantitative indicator, but does not allow considering the list of new functions or tasks and the complexity of their implementation by supervision (control) units.

According to [5, 18], the inspectorate of emergency prevention units performs the following functions:

- Organization and planning of work, general issues;
- Implementation of state supervision (control) and registration of documentation based on the results of measures;
- Administrative activity;
- Implementation of market surveillance measures;
- Preventive and informative work;
- Preparation of fire materials;
- Consideration of applications from legal entities and individuals;
- Work with local executive bodies and local self-government bodies.

High-quality performance of these functions requires a reasonable and optimal number of inspectors of emergency prevention units, which implies the use of appropriate research methods and determination of the required number of inspectors of emergency prevention units.

According to the results of the analysis of literary sources and research works carried out in this area [19, 12, 15, 16], it was established that there are a number of methods for establishing a justified number of employees - among them, there are such as: indirect rationing method, correlation-regression analysis, method of specific types of work labor intensity, a method based on technical and economic indicators, a method using tactical data of fire and rescue units.

The method of indirect rationing establishes the dependence of the number of employees on the characteristics of the object (population, number of buildings, danger of production facilities, etc.). This method is easy to use, but it has low accuracy, it allows obtaining averaged standards of numbers that take into account the volume and labor intensity of the work being performed. At present, methods of indirect rationing are widely used in determining the number of administrative units in various branches of economy.

The description of this method is given in works [2, 9, 13]. The authors obtained analytical ratios of the dependence of the number of fire protection workers on the population, the number of houses, industrial enterprises, the value of fixed assets, etc. The method is also applied in [6].

Correlation-regression analysis establishes the dependence of the number of employees on some factors (wages, material costs, business trips, the need to involve third-party organizations, etc.) [12]. This method allows building the dependence of the staff number on the influence of factors, but it is difficult to use, requires reliable statistics, and has no analogues for practical use.

To select the most significant factors affecting the staff number, a matrix of pairwise correlation coefficients is calculated. The correlation coefficients between the factors can be used to judge their relationship. At the same time, the absolute value of the correlation coefficient close to zero shows the insignificant influence of this factor. The final selection of factors is performed in the process of stepwise multiple regression analysis using a standard computer program.

On the basis of the numerical values of factors affecting the number of specialists, by applying the method of mathematical statistics for a given group of specialists, normative formulas for each management unit are constructed in the form of power (logarithmic) or linear multifactorial regression equations:

$$H = a_0 x_1^{a_1} \cdot x_2^{a_2} \cdot \ldots \cdot x_n^{a_n} \quad (1)$$

$$H = a_0 + a_1 x_1 + a_2 x_2 + \cdots + a_n x_n \quad (2)$$

where H - the norm of the number of specialists;
$x_1, x_2 \ldots, x_n$ - the importance of factors determining the number of specialists;
$a_1, a_2 \ldots, a_n$ - regression coefficients (factor coefficients) characterizing the degree of influence of the relevant factor on the number of specialists;
a_0 - constant coefficient of the regression equation (normative formula).

The type of functions of the connection between the staff number and the set of factors was selected in the process of processing these data on a computer with the help of specialized software for the automatic calculation of time and number norms. According to the regression equation, the calculated values of the staff number are obtained.

The method of labor intensity of specific types of work determines the number of employees based on the labor intensity of performing basic tasks and functions. This method requires reliable statistics and mathematical processing, due to which it gives a fairly reliable option. The method was applied in article [17] and used in previous research works [12, 15].

According to [10], at an enterprise with 50 or more employees, the employer creates a labor protection service in accordance with the standard provision approved by the central executive body, which ensures the formation of state policy in the field of labor protection.

At an enterprise with less than 50 employees, the functions of the labor protection service can be performed part-time by persons who have the appropriate training.

At an enterprise with less than 20 employees, third-party specialists with appropriate training may be engaged on a contractual basis to perform the functions of the labor protection service.

The scientific work [16] considered the composition of the structure of the fire safety service and proposed a model that allows determining the number of structural subdivisions at the facility; fire hazard of production, including categories of production, the number of working personnel, volumes of preventive and supervisory functions are considered.

The calculation of the number of employees of the fire safety service of the production structural unit S, depending on the explosion and fire hazard of the production, is carried out according to the formula:

$$S = 2 + \frac{P_{av} K_H R_O + R_P}{F} \quad (3)$$

where S - the number of employees of the fire safety service;
P_{av} - the average number of employees of the facility;
K_H - coefficient that takes into account the dangerousness of production;
R_O - annual time spent on preventive work by one employee of the fire safety service;
R_P - annual expenditure of time for visiting objects located outside the territory of the main enterprise to carry out preventive work by one employee of the fire safety service;
F - effective annual fund of working time of one specialist of the fire safety service.

A similar formula is used to calculate the number of preventive workers of the local or voluntary fire department of the settlement.

The coefficient K_H, which takes into account the fire and explosion hazard of production, is determined by the formula:

$$K_H = 2 + \frac{P_p + P_H}{P_{av}} \qquad (4)$$

where K_H - coefficient that takes into account the dangerousness of production;
P_p - the number of employees of the facility who perform work with an increased fire hazard;
P_H - the number of employees of the facility who work in explosive and fire-hazardous premises;
P_{av} - the average number of employees of the facility.
K_H can be a maximum of 3 if all employees perform work with increased fire danger and all work in explosion- and fire-hazardous premises.

The annual time expenditure R_p for preventive work by one employee of the fire safety service is determined by the formula:

$$R_p = 2\sum_{i=1}^{N_1} t_i n_i \qquad (5)$$

where *i* is the number of types of equipment, devices, etc.;
N_1 - the number of types of equipment, devices, etc., which require periodic inspection by an employee of the fire safety service;
t_i – time norm for inspecting a unit of equipment, devices, etc.;
n_i is the number of units of equipment, devices of the i-th type that require periodic inspection by an employee of the fire safety service.

The annual time expenditure R_p for visiting objects located outside the territory of the main enterprise for preventive work by one employee of the fire safety service is determined by the formula:

$$R_p = 2\sum_{j=1}^{N_2} T_j \qquad (6)$$

where N_2 – the number of production facilities located outside the territory of the main enterprise;
T_j – time spent (hours) traveling to the *j-th* object in both directions;
j - takes into account working time spent on vacation and is equal to 252 working days minus 24 vacation days multiplied by 8 hours, which is equal to 1824 hours.

The method based on technical and economic indicators, usually used in small commercial structures, establishes the number of employees by comparing production and economic indicators. The method requires constant monitoring and changes to staffing. It allows for the possibility of a non-rational result and is not applicable for large objects, organizations, and institutions.

In the method using tactical data of fire and rescue units, the number of inspectors according to this method is established depending on the frequency of departures of fire and rescue units. The method was used in a research paper [17], but it does not have sufficient approval and requires reliable statistics and mathematical processing.

Based on the results of the analysis of literary sources, it can be concluded that one of the criteria when assessing the number of inspectors is the laboriousness of performing a certain function, which in turn requires an analysis of the functions of the inspectors for further justification of the load standards necessary for their implementation.

The results of research on the justification of the number of employees using various approaches are given in the literature. At the same time, the question of the dependence of the number of inspectors of emergency prevention units on the load standards necessary for the high-quality performance of the corresponding function remains unexplored.

The purpose of this work is to establish the load standards (labor costs) depending on the type of task of the emergency prevention unit, as a scientific basis for the development of methodological recommendations for determining the load standards and calculating the required number of inspectors of the emergency prevention units.

In order to achieve the goal, the Ukrainian and foreign regulatory frameworks for calculating the required number of inspectors of emergency prevention units were analyzed, the tasks, functions, and time spent (labor intensive) for their implementation were investigated, methodological approaches (mathematical models) for data processing on calculation of the standard number of inspectors of emergency prevention units were studied and analyzed. Also, in order to achieve the set goal, it is necessary to collect, summarize, and process statistical data from territorial divisions regarding labor costs necessary for the implementation of a certain function. Investigatation and determininig the main tasks of the inspectorate of the emergency prevention units and developing methodological recommendations for determining the load standards and calculating the required number of inspectors of the emergency prevention units appears to be the relvant task.

The object of research is the implementation of emergency prevention functions by the inspectorate.

The subject of the research is the impact on the load standards (labor costs) of certain types of main tasks of the inspectorate of emergency prevention units.

The following procedure is proposed to establish the standards of loads necessary for the performance of the corresponding task or function:

- Establishment of a list of the main tasks and functions of emergency prevention units;
- Development of a survey questionnaire for collecting statistical data necessary during the justification of load standards for the implementation of the corresponding task or function;
- Summarization of the collected data according to load standards for the implementation of the corresponding task or function;
- Choosing a mathematical method for processing statistical data and establishing load standards for the implementation of the corresponding task or function;
- Development of methodological recommendations for determining load standards and calculating the required number of inspectors of emergency prevention units.

During the implementation of the proposed order, the basis should be the method, which consists in the assessment and further determination of an adequate ratio between the number of employees required to perform the functions assigned to them and the real labor costs (loads) necessary to perform such functions.

In order to determine the required number of staff and establish load standards for the implementation of the main tasks defined in [5, 11, 18], a list of the main functions of the inspectorate of emergency prevention units was established, which includes the following functions:

1. organization and planning of work regarding state supervision (control) in the field of man-made and fire safety, general issues;
2. implementation of state supervision (control) in the field of civil protection, fire and man-made safety and preparation of documentation based on the results of measures implemented;
3. accompanying protocols on violations of requirements in the field of civil protection, fire and man-made safety to the court;

4. implementation of measures of state market supervision;
5. campaigning and informational work in the field of civil protection, fire and man-made safety;
6. registration of materials on fires, formation of cases;
7. consideration of applications from legal entities and individuals on issues of civil protection, fire and man-made safety;
8. work with local executive bodies and local self-government bodies to comply with the requirements of civil protection, man-made and fire safety.

3 Results and Discussion

An approach based on the analysis of statistical information on working time costs [8] was chosen. For this purpose, relevant statistical data on labor costs, which are used by territorial units during the implementation of each of the functions defined above, have been collected.

Based on the results of the data analysis from the territorial divisions that perform the functions of supervision and control in the field of fire and man-made safety, the dependencies of the load standards for one economic entity depending on their total number have been established (Figure 3).

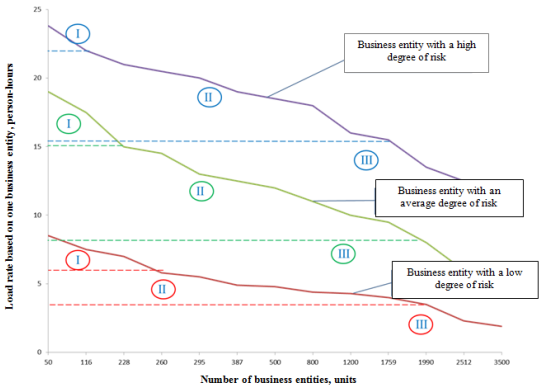

Figure 3. Dependence of load standards on the number of economic entities, in relation to which the functions of supervision and control are performed

Analyzing the dependence shown in Fig. 3 for all business entities, regardless of the degree of risk, two characteristic zones (I and III) can be distinguished for the reduction of regulatory loads for servicing one business entity. Zone I, when a small number of economic entities significantly increases the time allocated for the implementation of the function of supervision and control for one economic entity, can be explained by the surplus of time for the implementation of the specified functions for all economic entities; on the contrary, for zone III, when a large the number of economic entities reduces the time allocated for the implementation of the function of supervision and control per economic entity, it is explained by the lack of time for the implementation of the specified functions for all economic entities. The specified zones are areas of error during the justification of load standards for the implementation of the functions of supervision and control by the inspectorate. Therefore, they were not taken into account during the further processing of statistical data, and zone II was taken into account.

The method of mathematical statistics was used for data processing, the essence of which consists in the following steps.

Before starting the calculation, statistical data are checked, according to [7], for the presence of outliers and quasi-outliers using the Grubbs test.

In order to determine the average load standards for the implementation of the main tasks and functions of the inspection staff of emergency prevention units, empirical distribution functions of the studied speed of movement are constructed based on histograms, with a corresponding assessment of the parameters of the distributions (mean value and root mean square deviation).

The general theoretical approach to the construction of histograms and the calculation of their parameters is described in [14].

The load distribution parameters are calculated as follows. A sample of random values of loads $\{x\} = \{x_1,x_2,\ldots,x_N\}$ is formed, where N is the size of the sample of random values. Based on it, a grouped statistical series is built. To determine the number of intervals of groups L, the Brooks formula is used:

$$L = 5\lg N \qquad (7)$$

The minimum and maximum values of the sample $x_{min} = \min\{x_1,x_2,\ldots,x_N\}$ and $x_{max} = \max\{x_1,x_2,\ldots,x_N\}$ are found, and the length of the group interval (step of the histogram) is determined by the formula:

$$\Delta x = (x_{max}-x_{min})/(L-1), \qquad (8)$$

The limits of the *k-th* interval of the histogram are determined by the formulas:

$$x_{k-1} = x_{min} - 0{,}5\,\Delta x, \qquad (9)$$

$$x_k = x_{k-1} + \Delta x \qquad (10)$$

We determine n_k random variables from the sample $\{x\}$ that fell into the *k-th* interval $[x_{k-1}, x_{k-1} + \Delta x]$. For convenience, the limits of the intervals can be rounded, but the constancy of the step of the histogram Δx must be observed.

To construct a grouped statistical series of relative frequencies, the relative frequencies $p_k = n_k/N$ are calculated and the condition is checked

$$\frac{n_1}{N}+\frac{n_2}{N}+\ldots+\frac{n_L}{N}=1 \qquad (11)$$

For the graphical presentation of the histogram, the heights H_k of the rectangles of the histogram are calculated

$$H_k = n_k/\Delta x \qquad (12)$$

and the maximum height value $H_{max} = \max\{H_1, H_2, \ldots, H_L\}$ is determined.

On the abscissa axis of the histogram graphs, the starting point x_0 is selected and the scale is such that the segment $[x_0, x_L]$ fits completely. On the ordinate axis, the beginning of the reference is selected at point 0 and the scale is such that the segment $[0, H_{max}]$ is completely included. For each interval $[x_{k-1}, x_k]$, a rectangle of height H_k with base Δx is constructed. As a result, we get a histogram of absolute frequencies. To construct a histogram of relative frequencies, the value $p_k/\Delta x = n_k/N/\Delta x$ is used as the height of the *k-th* rectangle.

The mathematical expectation of the histogram μ_G is determined by the formula:

$$\mu_G = x_0 + \Delta x\left(\sum_{k=1}^{L} p_k K - \frac{1}{2}\right) \qquad (13)$$

The dispersion of histogram σ_G^2 is determined by the formula:

$$\sigma_G^2 = (\Delta x)^2\left[\frac{1}{12} + \sum_{k=1}^{L} p_k K^2 - \left(\sum_{k=1}^{L} p_k K\right)^2\right] \qquad (14)$$

Accordingly, the standard deviation is:

$$\sigma_G = \sqrt{\sigma_G^2} \qquad (15)$$

Average load standards for the implementation of the main tasks and functions of the inspector staff of emergency prevention units are determined by the formula:

$$\upsilon = \mu_G - \sigma_G \qquad (16)$$

Further, on the basis of the above approach, using formulas (7 - 16), calculations were made of the distribution of the costs of working time necessary to fulfill the functional duties of the inspector staff of emergency prevention units for each type of work.

Load standards for the implementation of the main functions of the inspector staff of emergency prevention units are calculated. In this way, for the first time, load standards (labor costs) were established for the implementation of the relevant functions of the inspector staff of emergency situations prevention units, the numerical values of which are given in Table 1.

Table 1: Load standards for the implementation of the main tasks and functions of the inspector staff of emergency prevention units

No.	List of main types of work	Load rate, man-hours
1	Implementation of state supervision (control) and preparation of documentation based on the results of measures, one business entity: ▪ for business entities with a small degree of risk ▪ for business entities with an average degree of risk ▪ for business entities with a high degree of risk	4.0 10.6 17.5
2	Filing lawsuits in court regarding violations of requirements in the field of civil protection, fire and man-made safety	2.1
3	Implementation of organizational and planning functions, functions of the state market surveillance body, campaigning and informational functions, functions regarding the preparation of materials on fires, functions regarding cooperation with authorities	74.9

Methodological recommendations for a differential approach when determining the required number of staff provide for the introduction of correction coefficients that take into account the peculiarities of the region: the number of serviced objects (registered), the number of fires (recording them, forming fire cases), the number of claims to court regarding violation of requirements established by law in the field of civil protection, fire and man-made safety.

The required number of staff includes the number of employees necessary for the implementation of the main tasks and is determined by the formula:

$$N = K \cdot \left[\frac{Q_{BEH} \cdot n_{obh} + Q_{BEM} \cdot n_{oba} + Q_{BEL} \cdot n_{obl} + Q_{AD} \cdot n_L}{m} + Q_t \cdot P_1 \cdot P_2 \cdot P_3\right] \quad (17)$$

where K is the coefficient that takes into account the time spent by employees on sick leave and vacations and is 1.15;

Q_{BEH}, Q_{BEM}, Q_{BEL} - total labor costs per business entity, for entities with high, medium, and low risk levels, man-hours;

Q_{AD} - total labor costs based on one lawsuit in court regarding violations of requirements in the field of civil protection, fire and man-made safety, man-hours;

n_{obh}, n_{oba}, n_{obl} – the average number of economic entities that are subject to supervision (control) during the year within the region;

m – annual rate of working time for one employee, with a 40-hour work week, h;

Q_t – general labor costs for the implementation of organizational and planning functions, functions of the state market supervision body, campaigning and information and explanatory functions, functions regarding the preparation of materials on fires, functions regarding cooperation with authorities in terms of compliance with the requirements of civil protection, fire and man-made safety (in man-hour);

n_L – the number of lawsuits in court for the region;

P1, P2, P3 are correction coefficients.

4 Conclusion

The work solves an actual scientific and technical task - determination of average load standards for the implementation of the main tasks of the inspectorate of emergency prevention units. As a result of the research, the following scientific and practical results and conclusions were formulated:

1. It has been established that the largest load standards (labor costs) during the activities of the inspectorate of the emergency prevention units in 2020-2021 fall on the implementation of state supervision (control) in the field of civil protection, fire and man-made safety and the drawing up of a declaration based on the results of the implementation of measures, as well as support of lawsuits in court regarding violation of requirements established by law in the field of civil protection, fire and man-made safety.
2. The procedure for substantiating the requirements of methodological recommendations for determining load standards and calculating the required number of inspectors of emergency prevention units is proposed. At the same time, it is planned to use the method, which consists in the assessment and further determination of the adequate ratio between the number of employees necessary for the fulfillment of tasks entrusted to them, according to the provisions of regulatory and legislative acts, tasks and functions, and the actual labor costs (load) necessary for their implementation.
3. The dependence of load standards for one economic entity depending on their total number is established. Such dependence shows that the small number of business entities that are served creates a surplus of time for the implementation of supervision and control functions, as a result of which labor costs are unreasonably overstated. On the contrary, the large number of business entities that are served creates a shortage of time for the implementation of the functions of supervision and control, as a result of which these functions may not be performed well and not in full.
4. It was established that during the calculation of the required number of inspectors, in order to ensure a differentiated approach, it is necessary to provide for the introduction of correction coefficients.
5. Load standards (labor costs) for the implementation of the relevant tasks and functions of the inspection staff of emergency prevention units were established, which are for:

Implementation of state supervision (control) and preparation of documentation based on the results of measures, per one business entity:

- For economic entities with a minor (insignificant) degree of risk – 4.0 man-hours;
- For business entities with an average degree of risk – 10.6 man-hours;
- For business entities with a high degree of risk – 17.5 man-hours.

Implementation of lawsuits in court regarding violations of requirements in the field of civil protection, fire and man-made safety - 2.1 man-hours.

Implementation of organizational and planning functions, functions of the state market surveillance body, campaigning and informational functions, functions related to the preparation of materials on fires, functions related to cooperation with authorities - 74.9 man-hours.

6. In further studies, it is expedient to continue the mentioned work in terms of approbation and determination of reliability limits of the calculation results according to the developed methodical recommendations.

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