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A. I. Kolosov[1], G. A. Kuznetsova[2], O. A. Gnezdilova[3]

MANAGEMENT OF WORK OF EMERGENCY AND RECOVERY SERVICES OF A GAS-DISTRIBUTING ORGANIZATION

Voronezh State Technical University
Russia, Voronezh, tel.: (4732)71-53-21, e-mail: kolossn@yandex.ru
[1]PhD in Engineering, Assoc. Prof. of the Dept. of Heat and Gas Supply and Oil and Gas Business,
[2]PhD in Engineering, Assoc. Prof. of the Dept. of Heat and Gas Supply and Oil and Gas Business
National Research University «Moscow State University of Civil Engineering»
Russia, Moscow, tel.: (4712) 22-26-17, e-mail: tgv-kstu6@yandex.ru
[3]PhD in Engineering, Assoc. Prof. of the Dept. of Heat and Gas Supply and Ventilation

Statement of the problem. When eliminating emergencies of gas supply systems, the most rational strategy for the actions of dispatching personnel is based on the management of the operation of emergency recovery services that allow one to monitor the restoration and to distribute limited material and technical resources considering changes in the parameters over time.
Results. On the basis of the mass service theory, an algorithm was developed to determine the optimal structure and parameters of the emergency service of the gas distribution company. To predict the parameters of the emergency services, a software is developed in the environment of the MatLab-Simulink package, which allows flexible control over the reliability of the equipment depending on the changing conditions of its operation. The program has advanced graphical representation of the results.
Conclusions. The use of the developed program allows one to increase the efficiency of the repair departments of a gas distribution organization and to maintain a high level of safety of operation of gas equipment.

Keywords: gas supply, accident, recovery, repair service, gas-distribution organization, *MatLab — Simulink*, modeling.

Introduction. The most viable strategy for managing dispatching staff that allows one to oversee restoration process and distribute limited material and technical resources considering changes in particular parameters over time is central to activities of emergency services.

1. Model of processing emergency claims based on the mass service theory. Each emergency has its own features and a certain mechanism [1, 2, 4, 8]. As an energency is being handled, there are the following problems a dispatcher has to address: 1) identifies damaged spots and scales; 2) collects the data on how an emergency develops; 3) evaluates an average time for handling an emergency; 4) evaluates risk-reduction costs: technical, environmental, economic, etc.; 5) identifies a few options and works out the most viable one.

Making an informed decision is challenging and complex. Therefore a dispatcher has to be properly informed and experienced and capable of making decisions within a short time period. It can be reduced by means of the following: 1) correct and timely prediction of emergencies and regular updates. This might be done by processing statistical data, modern monitoring tools or previously developed models; 2) preliminary calculations to allow one to identify spots and amount of damage of gas distribution networks caused by an emergency; 3) evaluating costs, average time of an emergency and choosing the most viable option for eliminating it considering different scenarios.

All of these enable a dispatcher to monitor works as well as to make changes to the way they are carried out. In order to determine the impact of an emergency, it is necessary to investigate degradation factors that affect gas distribution networks during their operation. These processes cause changes in the initial overall condition of elements of gas distribution system.

2. Model of handling emergency demands. Based on the theory of mass service, an algorithm of identification of an optimal structure and parameters of operation of emergency work to provide a level of safety of gas distribution networks was developed based on a necessary index of a restoration flow for a required level of safety. An emergency service was considered as a multi-channel mass service system where each emergency team is presented as a service channel [9, 13, 16, 17]. It is suggested that a ratio of mathematical anticipation of an amount of operating elements of the equipment group to the total number of elements in a group is employed as a criteria for evaluating an emergency:

$$K_i\left(t\right)=\frac{m_i^1\left(t\right)}{N_i}.$$

A workload index for handling emergency demands is as follows:

$$\rho=\frac{\sum_{i=1}^{n}\Pi_{зi}}{\sum_{i=1}^{n}\Pi_{вi}}, \tag{1}$$

where $\Pi_{зi}$ is a flow of emergency demands of the *i*-th equipment group, unit·year^{-1}; $\Pi_{вi}$ is a restoration flow of the *i*-th equipment group, unit·year^{-1}.

A flow of emergency demands of the *i*-th equipment group:

$$П_{зi} = \lambda_i m_i^1(t), \quad (2)$$

where λ_i is a parameter of a failure flows of the *i*-th equipment group, year $^{-1}$; $m_i^1(t)$ is mathematical expectation of a number of equipment elements that operates well at a time moment *t*.

A restoration flow of the *i*-th equipment group is as follows:

$$П_{вi} = \mu_i \left(N_i - m_i^1(t)\right), \quad (3)$$

where N_i is a number of the *i*-th element group of gas equipment, units; μ_i is a parameter of a restoration flow of the *i*-th group of gas equipment, year^{-1}.

A restoration flow of the *i*-th group of equipment by one team is as follows:

$$П_{в,исп,i} = \frac{\mu_i}{l}\left(N_i - m_i^1(t)\right), \quad (4)$$

where l is a total number of teams. An average workload index per one team is as follows:

$$\alpha = \frac{\rho}{l}. \quad (5)$$

An average number of teams dealing with emergency demands is as follows:

$$\bar{L} = \frac{\sum_{i=1}^{n} П_{зi}}{\sum_{i=1}^{n} П_{в,исп,i}}. \quad (6)$$

The likelihood of all the teams being free:

$$p_0 = \left(\sum_{k=0}^{l} \frac{l^k}{k!}\alpha^k + \frac{l^l}{l!}\frac{\alpha^{l+1}}{1-\alpha}\right)^{-1}. \quad (7)$$

An average number of emergency demands waiting to be handled:

$$\bar{N}_{Waiting\ lines} = l\alpha + \frac{l^l}{l!}\frac{\alpha^{l+1}}{(1-\alpha)^2} p_0. \quad (8)$$

An average time of waiting for emergency demands is as follows:

$$\bar{T}_{Line} = \frac{l^l}{\sum_{i=1}^{n} П_{зi} l!}\frac{\alpha^{l+1}}{(1-\alpha)^2} p_0. \quad (9)$$

An average time of emergency demands waiting to be handled and serviced is as follows:

$$\bar{T}_{Waiting\ lines} = \frac{l}{\sum_{i=1}^{n} П_{зi}}\alpha + \frac{l^l}{\sum_{i=1}^{n} П_{зi} l!}\frac{\alpha^{l+1}}{(1-\alpha)^2} p_0. \quad (10)$$

Fig. 1 shows a block scheme of the algorithm of determining a viable structure and parameters of the operation of emergency services.

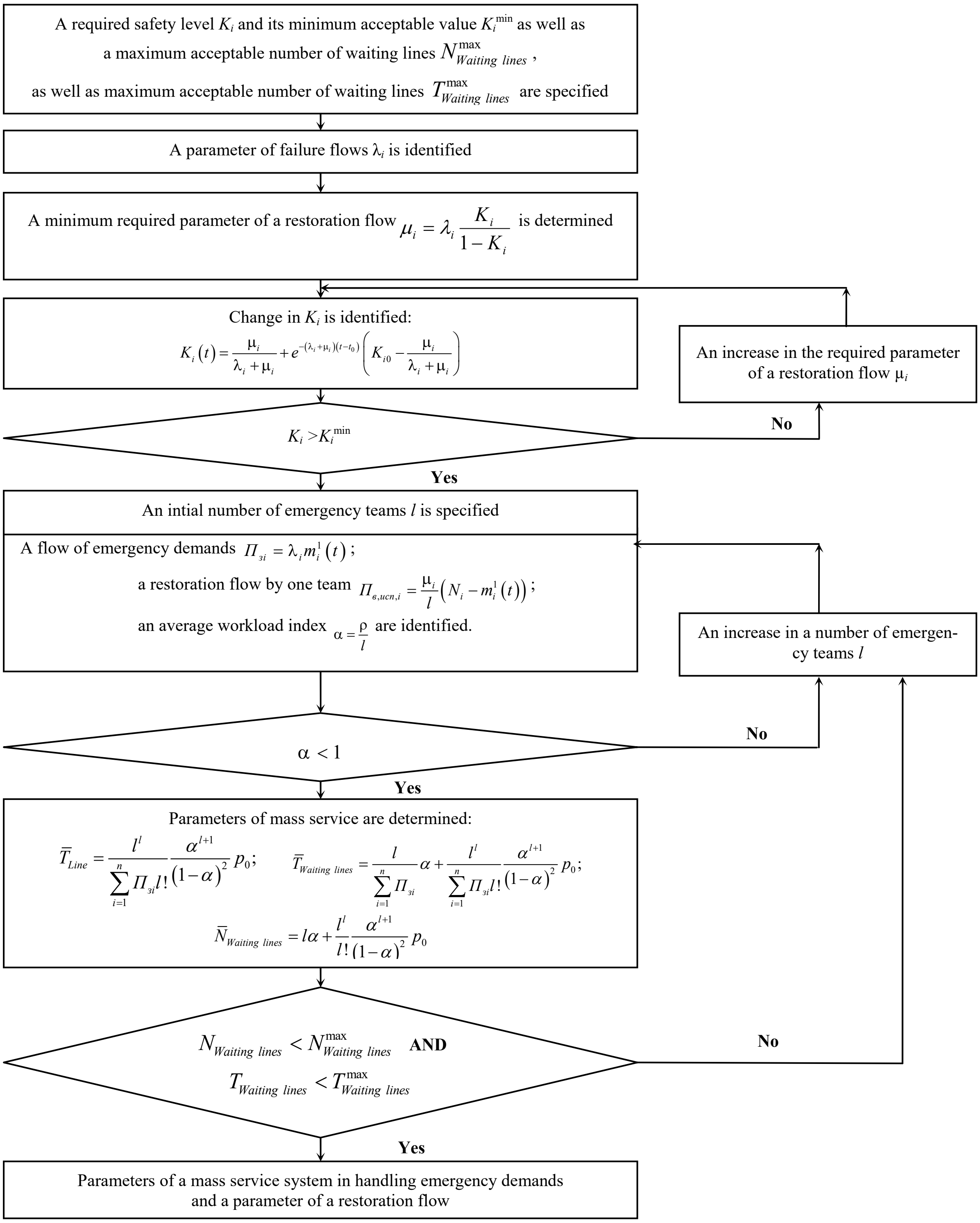


Fig. 1. Block scheme of the algorithm of determining an optimal structure and parameters of the operation of emergency services

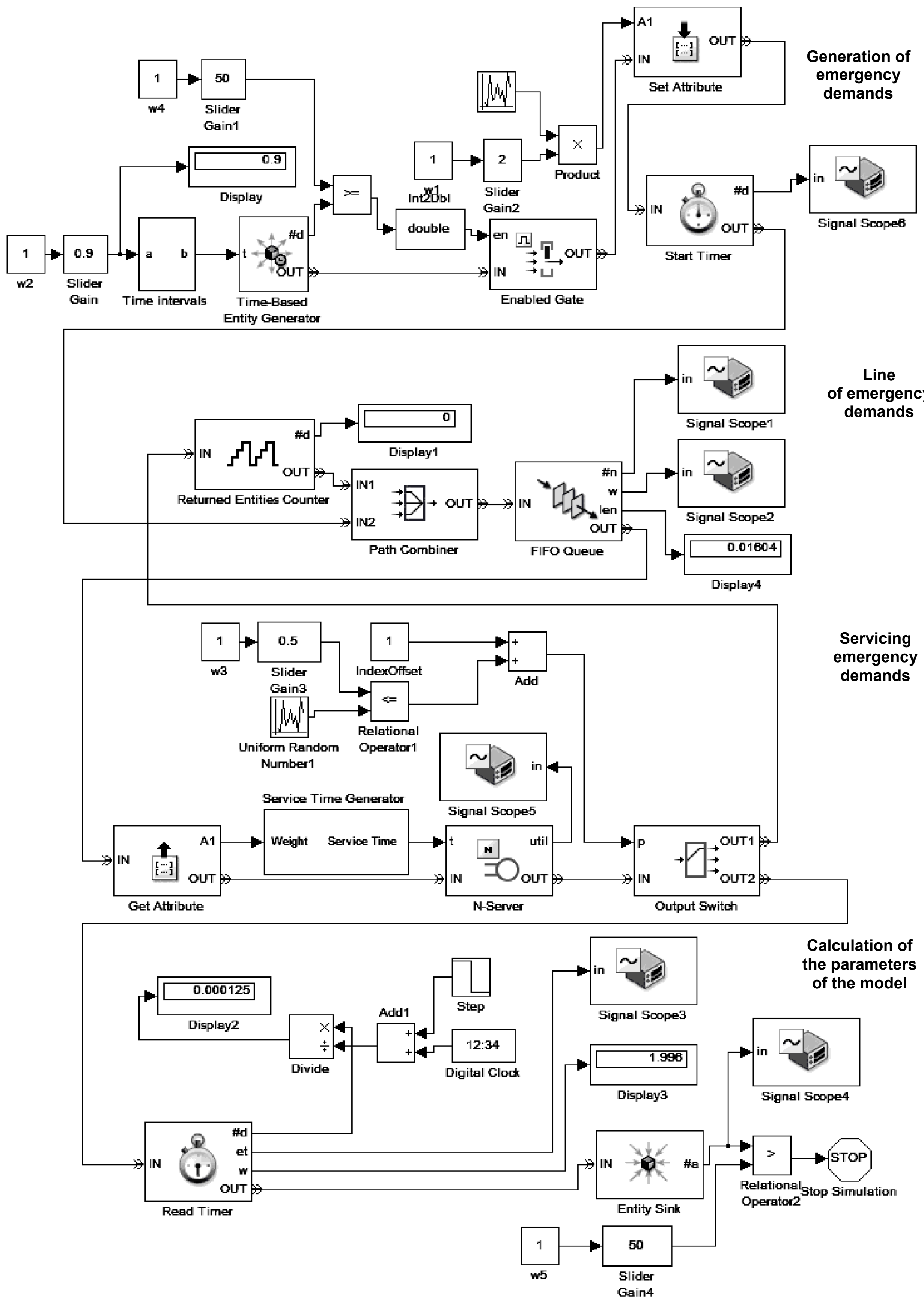


Fig. 2. Modulus of imitation modeling that implements an algorithm of determining an optimal structure and parameters of the operation of emergency services in the *MatLab — Simulink* software

The parameters of mass service systems handling emergency demands are identified based on the condition of a safety criterion not going under a threshold:

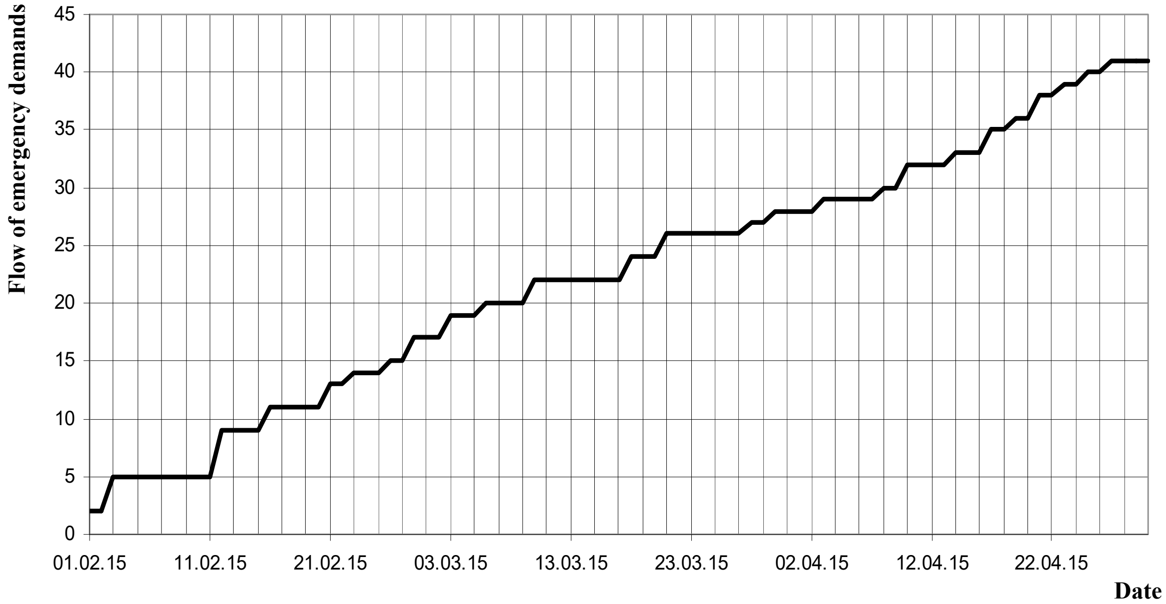
$$K_i > K_i^{\min}, \qquad (11)$$

and not going over thresholds of waiting lines and service time:

$$N_{Waiting\ lines} < N_{Waiting\ lines}^{\max} ANDT_{Waiting\ lines} < T_{Waiting\ lines}^{\max}. \qquad (12)$$

Fig. 3 shows a window of the modulus of imitation modeling with a graph of changes in a number of emergency demands waiting to be handled and being serviced.

a)



b)

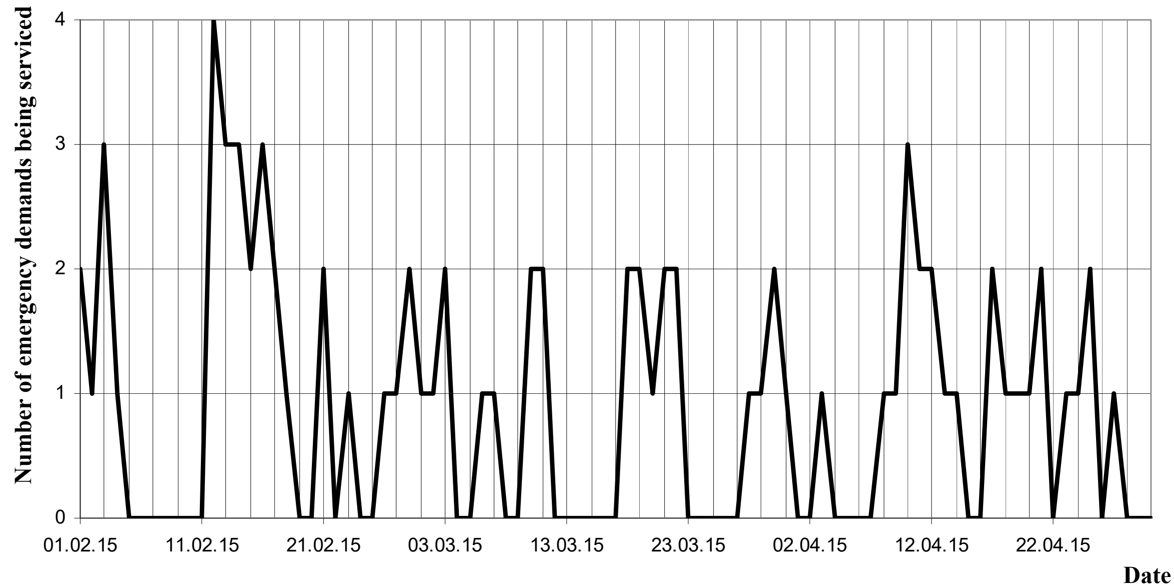


Fig. 3. Results of calculating the operation of emergency services of a gas distribution organization: a) an incoming flow of emergency flows; b) amount of emergency demands in the system

3. Imitation modeling of handling emergency demands. Using the developed imitation model of handling emergency demands, calculations of the operation of an emergency service of a gas distribution organization were performed using an example of Voronezh. Fig. 3 shows the results of calculating the operation of an emergency service of a gas distribution organization for two emergency teams.

As a result of modeling, all the characteristics of the operation of an actual emergency service of a gas distribution organization for the operation with an actual flow of emergency demands [5, 6, 10—12]. The sensitivity of each index to changes in the intensity of a flow of emergency demands and intensity of a flow of handling emergency demands was evaluated. This allowed flaws in the operation of repairing units to be identified and major directions in improving it to be determined.

Conclusions

1. Based on the theory of mass service, the algorithm of determining an optimal structure and parameters of the operation of emergency services of a gas distribution organization was developed.

2. In order to predict the parameters of the operation of emergency services, a software in the *MatLab — Simulink* package was developed to allow flexible management depending on changes in the operation conditions. The software is capable of advanced handling of graphical representation of the results.

3. The use of the developed program allows the efficiency of the operation of repairing units of a gas distribution organization to be improved and a safety level of gas equipment to be maintained at a high level.

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