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Improving the Link of the Gas and Smoke Protection Service on the Basis of Compressed Air Breathing Apparatus for Firefighters

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Abstract: *The study analyzes the search and rescue operations carried out by a link of the gas and smoke protection service of the Ministry of Emergencies. The relationship between the time of work and the flow rate of air in the cylinders of breathing apparatus with compressed air has been substantiated.*

Keywords: *link of the gas and smoke protection service, breathing apparatus.*

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1. Introduction

One of the main tasks of the links of the gas and smoke protection service (GSPS) in the event of a fire is to immediately provide assistance to people who are in danger. Exposure to flue gases containing toxic products of combustion and decomposition of various substances and materials is a particular danger to human life in fires [1].

However, when using breathing apparatus in an environment unsuitable for breathing, it is necessary to remember about the limited time of protective action of personal respiratory protective equipment (RPE). When searching in a smoky environment in underground or high-rise buildings in need of rescue, the gas and smoke defenders increase not only the intensity of physical activity, but also the psychological load caused by high responsibility for solving the task. In this case, the consumption of air (oxygen) in the cylinders of the RPE significantly increases, and the time of the protective action of the breathing apparatus decreases. [5]

To confirm this fact, the authors carried out a practical experiment of rescue operations in an environment unsuitable for breathing. The experiment consisted in determining the relationship between the time spent on rescue operations and the air consumption in the cylinders of compressed air breathing apparatus (RPE) during the search and rescue of "victims" in underground and high-rise buildings.

2. Methods and materials

The object of the research is rescue operations to search for and locate victims by the (GSPS) unit. The subject of the study is the duration of rescue operations (search for victims) and the air consumption in the (RPE) cylinders.

The purpose of the experiment is to substantiate the relationship between the time of rescue operations and the air flow rate in the (RPE) cylinders when searching, detecting and rescuing from tunnels and a high-rise building. To achieve this goal, it is necessary to solve the following tasks:

under the same experimental conditions, determine the time of search, detection and rescue of the "victims" by the (GSPS) link (separately from the tunnel and the high-rise building);

to fix the air pressure in the (RPE) cylinders during the same periods of the rescue operation in the metro and high-rise buildings;

to calculate the flow (consumption) of air by the pressure drop in the cylinders of the RPE and taking into account the operating time of the GDZS unit in an environment unsuitable for breathing for specific stages of rescue operations.

The composition of the (GSPS) link is 30 gas and smoke defenders, each aged from 21 to 40 years old, with different body types and physical fitness.

The place of the experiment is the training tower and the basement of the educational building of the Academy of the Ministry of Emergencies of the Republic of Uzbekistan.

Visibility conditions - maximum (100%) limited visibility (the glass of the panoramic mask is covered with a bandage).

"Victims" - the body of an "injured" adult imitates a simulator-dummy weighing 70 kg.

3. Results and discussions

The (GSPS) link carried out reconnaissance in uncovered rooms with the task of finding and rescuing the "victims" at a distance of 50 meters (first "in the basement", then "in the training tower") in conditions of maximum limited visibility. After the discovery of the "victim" link of the GDZS transported him in a supine position.

In the course of the experiment, the air flow rate (consumption) was constantly recorded by the air pressure in the (RPE) cylinders of gas and smoke defenders and by the time the (GSPS) unit stayed in an environment unsuitable for breathing for specific stages of rescue operations (search, finding, rescue, etc.). The search and finding of each "victim" (in the labyrinth and in the training tower) were carried out alternately, since the training simulators were placed in different rooms.

Between each switch-on and the work of the (GSPS) link, a 1-hour rest was organized until the body's forces and resources were fully recovered. Before being included in the (RPE), blood pressure and heart rate were measured in gas and smoke defenders. The initial pressure in the (RPE) cylinders is 290 atmospheres. The capacity of (RPE) cylinders is 6.8 liters.

The results from 30 people on average in the experiment are presented in table. 1 and 2.

Table 1 The results of the experiment to find, find and_save_ the "victim" from the basement 12 minutes. The total operating time of (RPE) is 45 minutes

Stage rescue works	**Time spent on the stage of rescue operations, *min***	**Consumption (consumption) of air by pressure in the cylinder (RPE), kgf/cm[1]**	**Middle consumption (consumption) of the lung demand valve (RPE), *l/min***	**The total time of the protective action of the PDM 290 atmospheric (RPE) was min.**
Entry up to a distance of 50 meters with maximum limited visibility	3	16	35	45
Search and location of the "victim"	1	9	35	
Putting on the "victim" of the rescue device	1	no more than 10	35	
Transportation of the victim in a supine position until reaching a breathable environment	7	40	35	
Total	12	no more than 75	no more than 40	

Table 2 The results of the experiment on searching, finding and_saving_ the "victim" from the training tower, which was on the 4th floor, 15 minutes. The total operating time of the (RPE) is 35 minutes.

Stage rescue works	**Time spent on the stage of rescue operations, *min***	**Consumption (consumption) of air by pressure in the cylinder (RPE), kgf/cm[1]**	**Middle consumption (consumption) of the lung demand valve (RPE), *l/min***	**The total time of the protective action of the PDM 290 atmospheric (RPE) was min.**
Entry up to a distance of 50 meters with maximum limited visibility	4	30	45	35
Search and location of the "victim"	1	10	40	
Putting on the "victim" of the rescue device	1	no more than 10	40	
Transportation of the victim in a supine position until reaching a breathable environment	9	50	45	
Total	15	no more than 100	no more than 45	

Based on the data obtained, a graph was drawn up of the dependence of the average air consumption in terms of pressure in the (RPE) cylinders and in terms of the time spent at each stage of rescue operations (Fig. 1).

As can be seen from the tables and graph, the time to search and find the "victim" from the training tower is about 1.5 times longer than the time to search and find the "victim" from the basement. However, it should be noted that the time of transportation of the victim from the basement in the supine position is almost 2 times shorter than that of the “victim” from the training tower of the 4th floor. Moreover, the final rescue time from the basement was 10% less.

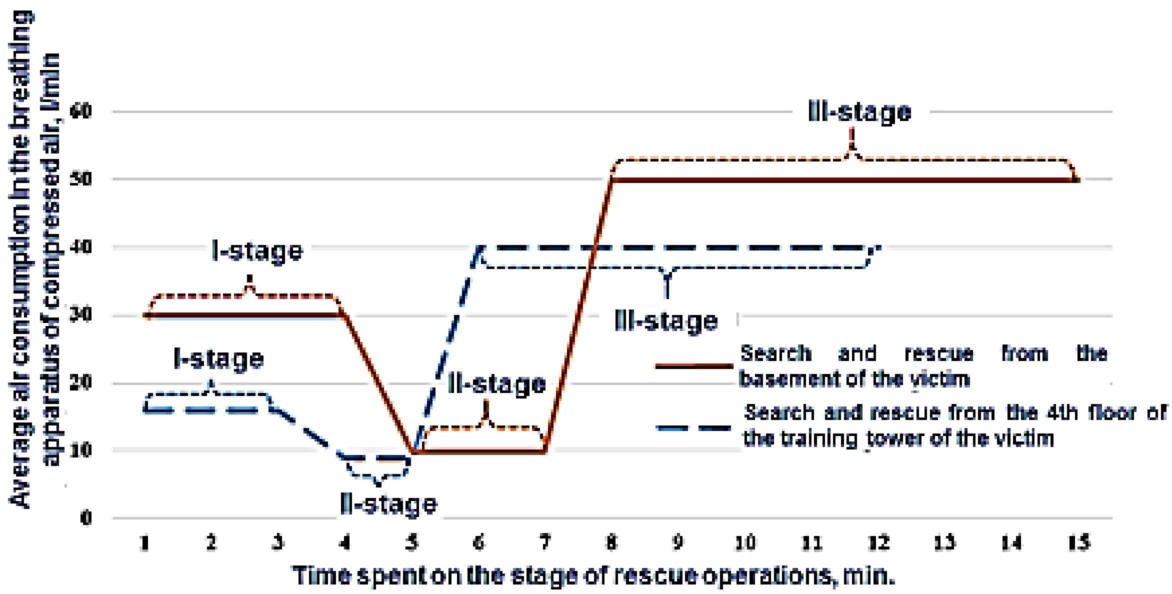

Fig. 1. Graph of the dependence of the average air consumption in the DASV cylinders of gas and smoke defenders and the time spent on the stage of the rescue operation: Stage I - movement to the place of probable location of a person (along a smoky corridor);

Stage II - search for the victim in the room;

Stage III - transportation of the victim.

4. Conclusions and recommendations

In this case, the following pattern is observed: air consumption by gas smoke defenders when searching and detecting c

The 4th floor of the training tower is higher than when performing similar actions from the basement. This can be explained by the fact that when searching for a damaged high-rise building, the gas and smoke defender has to move more intensively and in amplitude. It is quite possible that psychological factors (the significance of what is happening, lack of time, danger, limited visibility, physical activity, etc.) make the body work more intensively, increase the activity of the respiratory system (change in the frequency and depth of breathing) and, accordingly, consume more air from the cylinders. [4]

Now that we have our calculations for air consumption, we can look at the procedures for controlling the air of the breathing apparatus. In a large-scale search operation of a gas and smoke protection service, at a security checkpoint, a sentry can monitor the air consumption of the (GSPS) link, knowing the type of breathing apparatus cylinders used by the gas and smoke deflectors, and the consumption levels, as well as the use of a stopwatch. The execution time of the (GSPS) link is determined by the gas and smoke protector with the highest consumption level. For example, one gas and smoke protector has a consumption rate of 10 atm. per minute, and the other 6.8 atm. per minute. The control parameter here will be an element with 10 atm. per minute. The turning time to start reaching the 306 atm cylinder will be determined by calculating how long the time will last

(306 divided by 10 atm. Equals 33 minutes). Using this data, the guard at the security post can determine the appropriate times to enter, exit and leave a supply of air for an emergency. In this case, at the security post, the guard can use the rule of thirds used by divers in overhead conditions: one third of our air supply, one third and one third for emergencies. In the example above, this would be 11 minutes, 11 and 11 for emergencies.

If you think this is too conservative, you can use the half time plus five minutes method. To do this, subtract 5 minutes from 33, giving you 28 minutes. Half of that is 14 minutes. For this operation, the (GSPS) link made its way to the place of the fire for 14 minutes, and then returned back. This leaves a five minute standby time. Upon receipt of information, each gas and smoke defender checks the remaining air. If he can't see the gauge, then the security post will still have a good idea of keeping the air supply for the gas fume guard. More importantly, at the security post, a sentry can inform the gas and smoke defenders of the end of his missions and begin the exit on time, taking into account the unforeseen supply of air.

Conclusions. Controlling the (GSPS) link using the air consumption indicators of the breathing apparatus will be of great benefit to rapid response operations, as well as improve energy efficiency and safety when extinguishing a fire or searching for a victim in high-rise buildings, as well as a mass stay of people.

A gas and smoke protection service that is aware of the air consumption costs of breathing apparatus can help prolong the search for people. Each gas and smoke defender, who knows his flow rate, makes him realize how much air is left when the sound signal is triggered.

5. Literature:

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2. Order of the Ministry of Emergency Situations of the Russian Federation of January 9, 2013 No. 3 "On approval of the Rules for the conduct of emergency rescue operations by personnel of the Federal Fire Service of the State Fire Service when extinguishing fires using personal protective equipment of the respiratory and visual organs in an unbreathable environment.
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