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**ANALYSIS EXECUTION EMERGENCY- RESCUE WORK
FIREFIGHTERS IN SPECIAL PROTECTIVE MASKS ON A HEIGHT**
(presented DSc Abramov Yu.A.)

Vindicated, that the organization of professional activity of firefighters in special protective masks requires to surely it was taken into account that time of execution of the operations on a height depends on not only from level of preparedness, but also extremality of situations, related at first with the rescue alive people. Analysis time execution basic operations in the insulating machines showed, that they can be described with the help β -distribution. On value skewness distribution time of execution typically operations, we can reason about rescuers training level.

Keywords: firefighters in special protective masks, operation, execution time, β - distribution, skewness.

Problem statement. As a result of a large number of high-rise buildings in the cities, the firemen faced with the problem of extinguishing fires and rescuing people at altitude. This is dangerous because fires develop at high speed with the release of smoke and hazardous chemicals. These crash-rescue operations require participation of smoke divers (SD).

Analysis of recent researches and publications showed, that most often the study, how features firefighters in special protective masks related with their motivation [1,2] or with ability to risk during the execution tasks on the most dangerous, extreme conditions [3], influence on results his activities. In this case to fail to take into account somehow the work firefighters in special protective masks the basement and living spaces significantly differs from their activities in execution combat missions in the insulating devices on the height.

On the other hand, in [4,5,6] analysed features execution typical operations on insulating devices without determination features, which are related not only with the work in unusable for breathing environment. Effective enough for determining practical recommendations there is the approach which is based on the analysis of distribution time execution of the standard operations [6]. In [7,8,9] marked the need to consider the factors associated with the need for concentration, speed and precision of decision-making work firefighters in special protective masks the shortage of time and information, the impact of emotions of a negative character, and the like. In order to address these shortcomings in [10] were disclosed regularities of work of rescuers in the insulating apparatuses, but in their analysed the results of firefighters

in special protective masks works during the rescue of people and extinguishing fires in basement and socle premises.

At the same time, personnel exist is in insulating apparatus also on time rescue operations and extinguish fires multi-storey structures, including working from the outside of the building.

Statement of the problem and its solution. Based on the foregoing, it is necessary to disclose patterns of activities of firefighters in special protective masks at the height of and analysed received the dependences of time execution of separate operations, which are characteristic of this type of rescue work. To solve the set tasks was the experimental researches, which happened with regard functional-target information [11], which determined the conditions in which firefighters in special protective masks conduct the rescue operations: a fire engulfed a four-storey building, the ways of ascent to the main floor by the staircases cutting off by fire. In connection with the latter condition the link is moving in the window of the fourth floor on the assault ladders suspended from a "chain". Before personnel put the problem: to conduct a search and evacuation of victims from the fourth floor. The personnel works in regenerative breathing apparatus (RDA).

In this sequence the decision set task limitations associated with the use of a four-storey building is significantly weakened, and the resulting sentences can be used for preparation of link SD to work at floors to whom do not get existing auto ladders. So, we can assume that the work firefighters in special protective masks works for evacuation of victims in a twelve-story buildings (typical of modern housing estates) have same character with learning situations.

Original position: link built near SD's car, the commander and two getdemodata in RDA, the guard on the post without RDA, communication facilities equipment, special technical arms near SD's car.

The solution scenarios represent a consistent implementation of the following stages:

- training link for work (stage 1);
- lifting on the assault ladders in a window of the fourth floor (stage 2);
- insurance victim in consciousness (stage 3);
- descent victim in consciousness with insurance (stage 4);
- finding the victim in conditions of invisible:
 - * without coupling (step 5.1);
 - * with the coupling (step 5.2);
- insurance victim unconscious (stage 6);
- the descent of the victim without consciousness (stage 7);
- the descent link with cleaning stairs (step 8).

In preparing link to work at the command of the link's commander it will be equipped with a means of communication (portable radio), lighting (lantern), insurance (carbines and ligaments), special weapons. The commander of link assigns the guard on duty security and specifies his location. Then

personally supervises the conduct of operational checks (after the command: “Machines to check!”) RDA subordinates and controls the correctness of their inclusion in the apparatus (after the command: “devices on!”), checks the pressure of oxygen in the cylinder in front of the entrance and quality of radio communication with the guards on duty security. In the second stage (the lift to 4th floor) link performs the ascent with using assault ladders, hanging from a “chain”. After reaching the last firefighters in special protective masks the 4th floor goes to the next step — the insurance of the victim in consciousness. Meanwhile, after commander give a command one of the firefighters in special protective masks performs insurance victim in consciousness one of chosen him ways. In the next step firefighters in special protective masks, which carried out the insurance of the victim, with an attached on carbine rope for rescue at the command of the commander of link down on assault ladders the stairs the victim in consciousness, supporting his legs. After the descent of the victim in the minds, the commander makes decision that the link which includes two people to conduct reconnaissance and coordinates the communication of their actions with the guards on duty security.

For simulate the conditions of complete invisibility, personnel's goggles helmet –masks closed. Link, moving on the floor, finds a mannequin and dragged it to the window. After that, link knitted double loop on dummy, and he down on ground. The final phase includes the descent of the link with the cleaning of stairs.

The received experimental findings and results, of their statistical processing are shown in table 1. In addition, in column 3 the results of the insurance of the manikin during the practical training in conditions of good visibility.

Tab. 1.

The results of the research work of firefighters in special protective masks at altitude link	The execution time of stage									
	1	2	3	3	4	5.1	5.2	6	7	8
1	2	3	4	5	6	7	8	9	10	11
1	290	285	100	14,4	100		24	175	45	145
2	310	365	120	23,2	155		36	200	95	265
3	255	295	85	14,2	65	17,5		105	50	265
4	287	395	110	22,1	175	18		125	130	245

Продовження табл. 1.

1	2	3	4	5	6	7	8	9	10	11
5	315	450	170	40	200		44	130	155	305
6	303	355	125	13,7	145	19		170	75	220
7	295	470	168	47,5	190	19,5		230	135	330
8	195	410	165	42,1	180	20,5		235	140	250
9	210	322	125	21,1	145		9,5	160	55	255
10	343	310	110	24,8	105	24		135	65	295
11	350	425	130	21,5	170		44	180	105	290
12	305	335	92	13,1	135		41,5	140	70	295
13	270	340	137	20,7	140		28	195	60	250
14	330	375	145	25,4	170		34	180	100	320
15	235	380	155	20,1	155	14		215	85	220
16	360	335	155	12,1	85	23		190	65	160
17	355	435	127	37,3	210	30		175	160	345
18	215	384	175	18,5	165		38,5	205	85	280
19	270	348	110	31,2	160	19		125	75	265
20	245	315	120	29,4	140	7,5		170	40	140
21	310	345	105	15,8	150		49	80	70	190
22	155	390	195	32,6	165	125		230	100	320
23	190	350	115	16,4	160		39,5	210	85	305
24	285	395	95	18,5	175		57	185	120	290
\bar{t}	278,3	367,0	130,6	23,99	151,7	18,71	37,08	172,7	90,21	260,2
G	55,97	48,41	29,44	9,90	34,72	5,77	12,38	41,02	34,53	56,83
Sk	-0,52	0,36	0,50	0,94	-0,86	-0,05	-0,78	-0,46	0,59	-0,79
Ex	-0,46	-0,40	-0,60	0,04	0,79	0,96	1,31	-0,33	-0,59	-0,03
Min	155,0	285,0	85,00	12,10	65,00	7,50	9,50	80,00	40,00	140,0
Max	360,0	470,0	195,0	47,50	210,0	30,0	57,0	235,0	160,0	345,0
α	2,508	2,000		2,000	2,875	2,822	2,906	1,208	2,000	2,426
β	2,000	3,095		6,269	2,000	3,143	2,229	1,000	3,915	2,000

Analysis of the results showed that among those operations, which should be given special attention to reduce time, a special place is the link's training before work.

The timing of this operation

$$F(t_1) = 155 + 205 \cdot \beta(x_1; 2,508; 2,000) \quad (1)$$

in the course of experiments investigating the nature of work of firefighters in special protective masks at altitude (see Picture 1) was very large (two and a half to six minutes), and the operation itself, with all its assumed secondary importance, occupied to 20% of the length of the solution of the entire job as a whole. Cause negative skewness distribution in irregularly work, with at altitude are held.

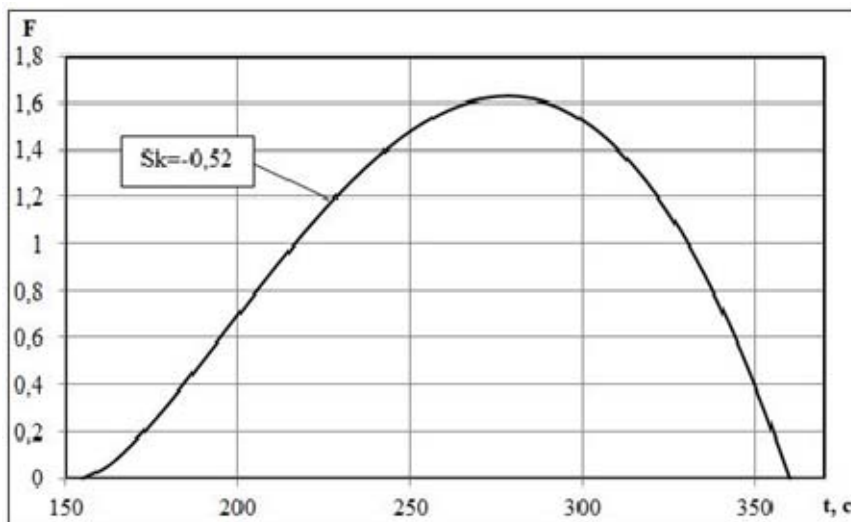


Fig. 1. The distribution of the time of preparation of SD's link for rescue operations at altitude

The comparison (see Fig. 1) distributions of the time to raised the link in the window of the fourth floor

$$\beta(x_2; 2,000; 3,095) = \frac{1}{B(x_2; 2,000; 3,095)} \cdot \int_0^{x_2} y^{1,000} \cdot (1 - y)^{2,095} dy \quad (2)$$

and the execution time of the final operation of the process (descent with the cleaning of the stairs)

$$\beta(x_8; 2,426; 2,000) = \frac{1}{B(x_8; 2,426; 2,000)} \cdot \int_0^{x_8} y^{1,426} \cdot (1 - y)^{1,000} dy. \quad (3)$$

Showed, that in case (2) the skewness of the distribution were positive (this indicates that the subjects were generally coordinated, strong and professionally trained), and in the case of (3) is negative.

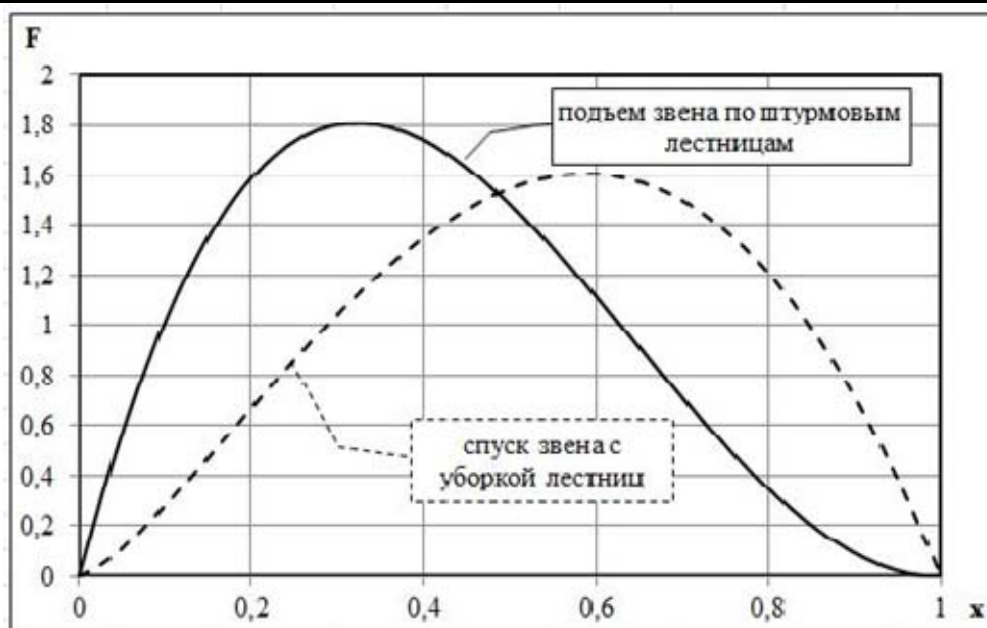


Fig. 2. Distribution of time (in coded variables) ascent (descent) of link SD

Given this, we can conclude that it is necessary to pay special attention to the improvement of the endurance of rescuers.

Comparison of distribution of time of descent of the victim in consciousness (in the role of last was were living person)

$$\beta(x_4; 2,875; 2,000) = \frac{1}{B(x_4; 2,875; 2,000)} \cdot \int_0^{x_4} y^{1,875} \cdot (1-y)^{1,000} dy \quad (4)$$

with distribution of time descent the dummy

$$\beta(x_7; 2,000; 3,915) = \frac{1}{B(x_7; 2,000; 3,915)} \cdot \int_0^{x_7} y^{1,000} \cdot (1-y)^{2,915} dy \quad (5)$$

confirmed (see Fig. 3.) that the performing heavy responsible (associated with the life of another person) operation is characterized by a negative on skewness on the distribution, despite the fact that the respondents had good preparation for it, as evidenced by the positive skewness of escape from the fourth floor window mannequin.

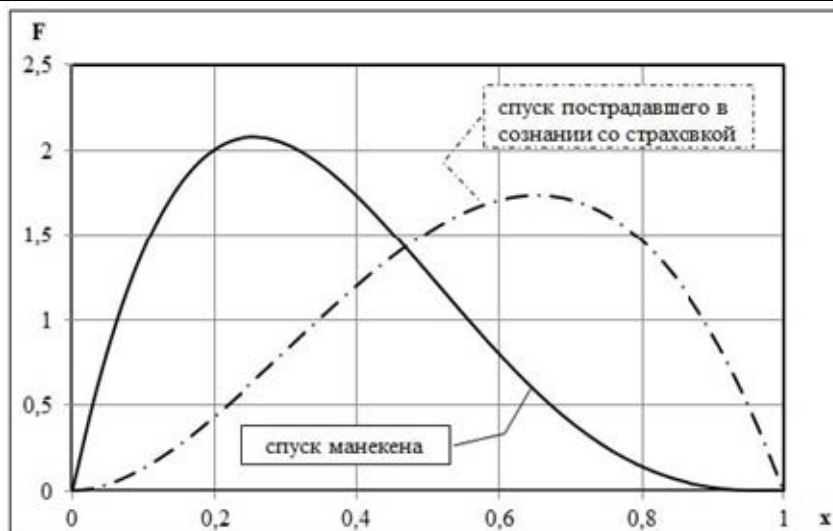


Fig. 3. Distribution of time (in coded variables) the descent of the victim link GDZS

Analysis of the peculiar properties of victim's insurance (see Fig. 4) showed that, despite the good execution this operation personnel in normal conditions, which evidenced by the pronounced positive skewness ($Sk_{3'} = 0.94$) of the allocation of time insurance firefighters in special protective masks, who work without coupling of the dummy in good visibility

$$\beta(x_{3'}; 2,000; 6,269) = \frac{1}{B(x_{3'}; 2,000; 6,269)} \cdot \int_0^{x_{3'}} y^{1,000} \cdot (1 - y)^{5,269} dy, \quad (6)$$

existing on fire of external factors associated with lack of visibility and with interaction between personnel working in the coupler, lead not only to a substantial increase in the execution time of such an operation ($\bar{t}_{3'} = 23,99 \text{ c} \ll \bar{t}_6 = 172,71 \text{ c}$), but also to negative skewness distribution

$$\beta(x_6; 1,208; 1,001) = \frac{1}{B(x_6; 1,208; 1,001)} \cdot \int_0^{x_6} y^{0,208} \cdot (1 - y)^{0,001} dy. \quad (7)$$

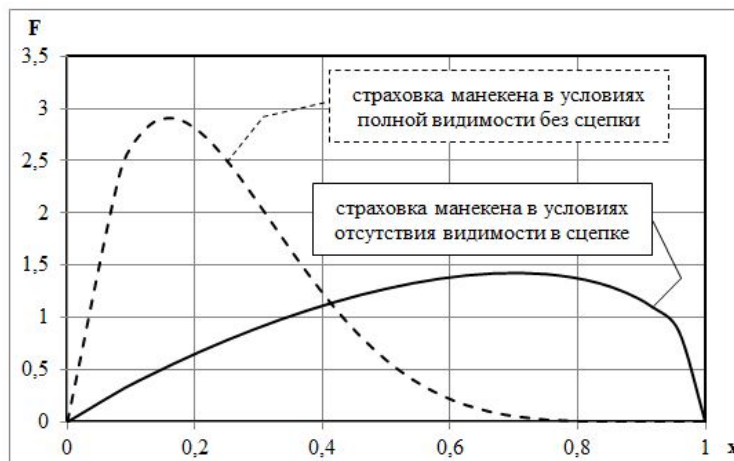


Fig. 4. Distribution of time (in coded variables) of insurance the victim in unconscious (dummy) link GDZS

At the same time, it is necessary to consider the case (see Fig. 5.) when rescuers performed extremely saturated operation (insurance injured in consciousness before its descent along the exterior wall of a multistory building with the help of rescue rope).

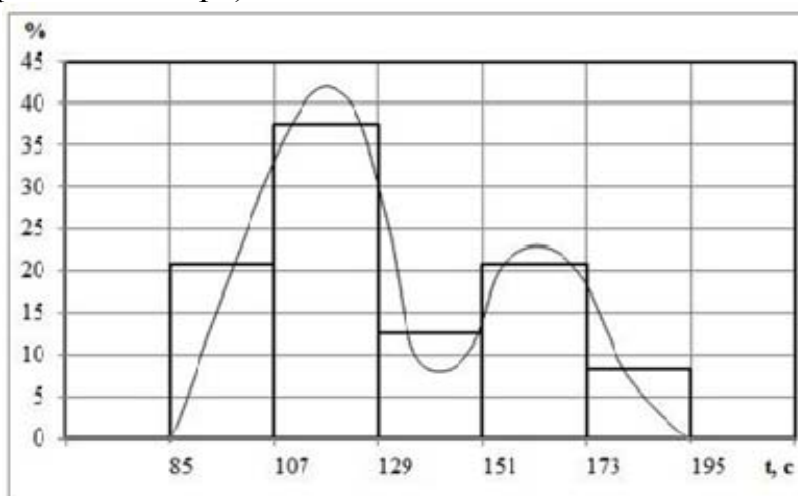


Fig. 5. Histogram of distribution of time of insurance of the victim in the minds of well-trained personnel before descending along the external walls of high-rise building

In particular, as in the case of the removal of the victim in the minds from indoor smoke [10], a characteristic feature of the distribution of the execution time emotionally saturated operations (binding rescue hinges on human who will then evacuate using rescue rope along the outer walls) well-trained personnel (norm perform similar operations on a mannequin in conditions of good visibility, the time which distribution is shown by the dashed line in Fig. 6, the majority of the subjects taken excellent and good evaluation) is the presence of two peaks.

Analysis of the results shows that some subjects (about 10-20%) in extreme situation dramatically worsens the results implementation of even well-established in the process of preparing special tactics, not to mention those operations, the order in which you will have to choose independently, based on the specific situation. In addition, was considered (see Fig. 6) features of the looking-for victim in a room with dimensions of about 30 m².

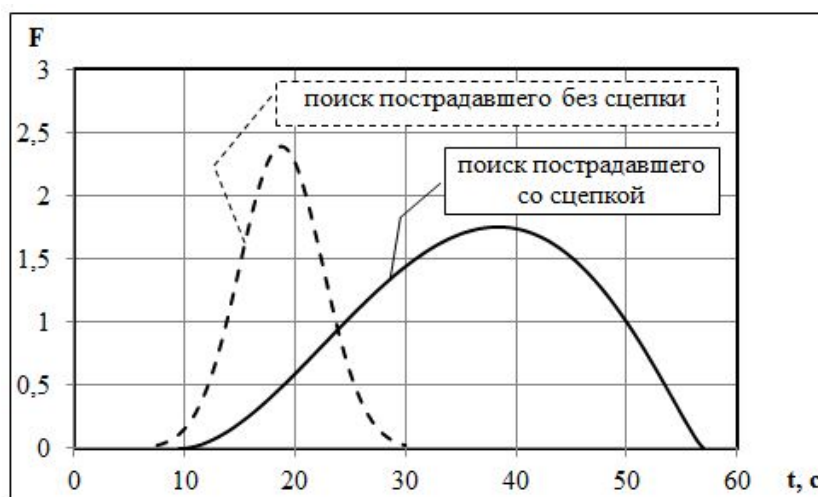


Fig. 6. The distribution of search time the victim in the room with limited space

He was always in the same place, and firefighters in special protective masks worked in conditions that mimicked the lack of visibility (eyepieces facial parts were closed tight lightproof material).

The difference between links was the fact that in one case (stage 5.1) personnel worked without a hitch, and in another (stage 5.2) – with a hitch.

Analysis of the results shows that even in small spaces the presence of coupling significantly prevented carrying out of search works. So, we can make a conclusion about expediency of the movement, when possible, along the hose line or guide rope.

Conclusions:

- distribution times of the simple operations have a bevelled character and can be described using a β -distribution, which have parameters reflecting the positive skewness with well-trained rescuers and negative - in case of insufficient;

- the magnitude of skewness time distribution of the typical operations you can judge the level of preparedness of rescuers. Then, more positive the value, of this indicator, when we assess run time, the greater the number of rescuers performs considering military operation with results close to the best. This suggests about further training will not give much better results. And conversely, the greater the module of this metric for distributions with negative skewness (when evaluating execution duration), the greater will be improved results after a workout;

- the character of the distribution of time is very strongly influenced by psychological factors, which primarily is associated with the fear of firefighters special protective masks to cause injury to a living person (the victim). In the case of insurance of the victim in the minds before its descent along the exterior wall of a multi story building with the help of rescue rope almost 20% of firefighters in special protective masks the presence of extreme situation had dramatically worsened the results of this operation, in which they are when working without extreme loads, have good training.

The direction for future research. It is advisable to explore the features of the specific version of rescue works in unbreathable environment with the use of simulation modelling.

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Аналіз проведення аварійно-рятувальних робіт газодимозахисниками на висоті

Показано, що організація професійної діяльності особового складу газодимозахисної служби вимагає обов'язкового врахування того, що на час виконання операцій, які пов'язані з проведенням аварійно-рятувальних робіт на висоті, впливають не тільки рівень підготовленості, але й екстремальність ситуації, пов'язана з рятуванням живих людей. Аналіз часу виконання основних операцій в ізолюючих апаратах показав, що вони можуть бути подані за допомогою β -розподілу. За показником скошеності розподілу часу виконання типових операцій можна оцінювати рівень підготовленості рятувальників.

Ключові слова: газодимозахисники, операція, час виконання, розподіл, скошеність.

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Анализ проведения аварийно-спасательных работ газодимозащитниками на высоте

Показано, что организация профессиональной деятельности газодимозащитников требует того, чтобы обязательно было учтено, что на время выполнения операций, связанных с проведением аварийно-спасательных работ на высоте, влияют не только уровень подготовленности, но и экстремальность ситуаций, связанная, в первую очередь со спасением живых людей. Анализ времени выполнения основных операций в изолирующих аппаратах показал, что они могут быть описанными с помощью β -распределения. По величине скошенности распределения времени выполнения типовых операций можно судить об уровне подготовленности спасателей.

Ключевые слова: газодимозащитники, операция, время выполнения, распределение, скошенность.