UDK 331. 101

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DEVELOPING OF SUGGESTIONS ON TRAINING SMOKE DIVERS FOR REALIZATION OF FIRE – RESCUE WORKS IN BASEMENTS AND GROUND FLOORS

(presented by PhD Stsakal B.)

In the article are proposed recommendations including standard indicators on training smoke divers for realization of fire – rescue works in a case of fire take place in basements and ground floors. For this ground were used the implementations of corresponding operations got as a result of statistical analysis of results physical design of activity of Gas rescue service links

Keywords: smoke divers, basement, conformities of activity, distributive law.

Problem statement. Realization of fire-rescue works in case of fire take place in basements and ground floors is provided by smoke divers, who are able to execute put tasks in Respiratory Protective Equipment (RPE) in the conditions of high smokiness limit visibility and limit space [1]. Hereupon conformities of implementation of such activity have features that must be taken into consideration both at planning and estimation of full complex wrecking and in the process of rescuer training.

Analysis of recent researches and publications, showed that nowadays for perfection of training for Gas rescue service staff mostly are used results of investigation of psychophysiological qualities that require prior training [2,3]. Talking about training of smoke divers in basements [4] based on analysis of expert opinion was found out that main attention must be focused on training of endurance, ability to orient in space and perfection of unit cohesion. The results that were got are used for creation of training base [5] but don't allow us to control the level of smoke divers training. For this are used standards but in this case they evaluate only timing of performing of complex task connected with passing of fire area psychologic training [6]. Relating to battle deployment of rescue equipment is shown [7] that knowing laws of distributing time of performing operations or processes normative evaluations can be divided:

- in a case of normal allocation as

$$t_5 = \bar{t} + \sigma \cdot \Phi^{-1}(\hat{P}_5); \quad (1)$$

$$t_4 = \bar{t} + \sigma \cdot \Phi^{-1}(\hat{P}_4 + \hat{P}_5); \quad (2)$$

$$t_3 = \bar{t} + \sigma \cdot \Phi^{-1}(\hat{P}_3 + \hat{P}_4 + \hat{P}_5), \quad (3)$$

where $t_{5(4,3)}$ – timing of task performing, if reached standard could be evaluated as «excellent» («good», «satisfying»), c; $\bar{t}$, σ - expectancy and standard error of the mean, c; $\hat{P}_5, \hat{P}_4, \hat{P}_3, \hat{P}_2$ – average weighted ratings of share (frequency) all possible results, corresponding to as «excellent», «good», «satisfying» and «not satisfying»; Φ^{-1} – meaning of inverse distribution of normal allocation;

- in a case of skewed distribution as

$$t_5 = t_{min} + F^{-1}(\hat{P}_5) \cdot (t_{max} - t_{min}); \quad (4)$$

$$t_4 = t_{min} + F^{-1}(\hat{P}_5 + \hat{P}_4) \cdot (t_{max} - t_{min}); \quad (5)$$

$$t_3 = t_{min} + F^{-1}(\hat{P}_5 + \hat{P}_4 + \hat{P}_3) \cdot (t_{max} - t_{min}), \quad (6)$$

where F^{-1} – inverse function β-allocation; t_{min}, t_{max} – min and max timing of task performing.

Wherein in [7] is marked that good training skills of staff corresponds with positive skewness distributing time of performing operations and insufficient to negative one.

Thus, for the direct ground of the suggestions related to training smoke divers for realization of fire - rescue works in basements and ground floors it is necessary to know distributions of timing of performing basic operations. In addition, they can be used for realization of modeling imitation of Gas rescue service links activity.

Setting the problem and its solution. On the basis of above mentioned were set tasks of discovering regulatory realization of fire-rescue works by smoke divers in case of fire take place in basements and ground floors with further explanation of recommendations for training.

The most exact regularities would be got as a result of statistical estimation of results of implementation of separate operations during the rescue of victims and extinguishing of the real fires in building that have difficult structurally-plan decisions. However such approach it is practically impossible to carry out, foremost, because it is difficult to differentiate separate operations during operative work.

On this basis, for the design of the examined type of battle work were used practical trainings of smoke divers in smoke and heat training facility consisting of [5] areas allowing to design activity of smoke divers in an industrial zone and dwelling apartment, basement labyrinths and trestle. Using a smoke sword was provided the high concentration of smoke and accordingly limited visibility. Using loud speakers was played noise connected with emergency situation (bringing down of constructions, screaming of victims etc.). On introductory info that was used during realization of experimental researches, a fire happened at the ground floor of building. Smoke divers had a

task to make a reconnaissance in this building and after a discovery a victim in one of apartments (this role was executed by a model) to take out to a fresh air. Depending on pointing of head of experiment victim can be as model as one of members of link [8].

After the training of link, operative verification and plugging in regenerative respiratory vehicles (stage № 1) a link enters in smoke training facility and moving along a right capital wall [1] inside building, is making a reconnaissance (stage № 2), disconnecting electro-knife-switches and warners of fire, recovers pipelines (stage № 3). In living accommodation is making reconnaissance (stage № 4.11 - executed in case if a victim is in a basement labyrinth) or search of victim (stage № 4.2). If victim is found in living accommodation of smoke and heat training facility a model (stage № 5.21) or one of link (stage № 5.22) is taking out using the same way a link came in. In case when victim is not found in living accommodation, a link, moving up farther, is searching a victim in a basement labyrinth (stage № 4.12). After a discovery using like the stage № 5.21 and № 5.22 he is taking out to the fresh air (accordingly the stages № 5.11 and № 5.12). Difference consist of that a finishing area a link passes on trestle that has grounds on different levels and containing plenty of turns.

The results of statistical analyses of experimental results characterizing timing of performing considered operations are shown in Table 1.

Using analogy with [9], taking into consideration (4÷6) was evaluated the possibility of using β-allocation for describing results. For getting parameters α and β basic data was set in diapason from 0 till 1 suing coding:

$$x_i = \frac{(t_i - t_{imin})}{\Delta t_i}, \qquad (7)$$

where $\Delta t_i = t_{i\,max} - t_{i\,min}$.

Table 1. Results of experimental researches

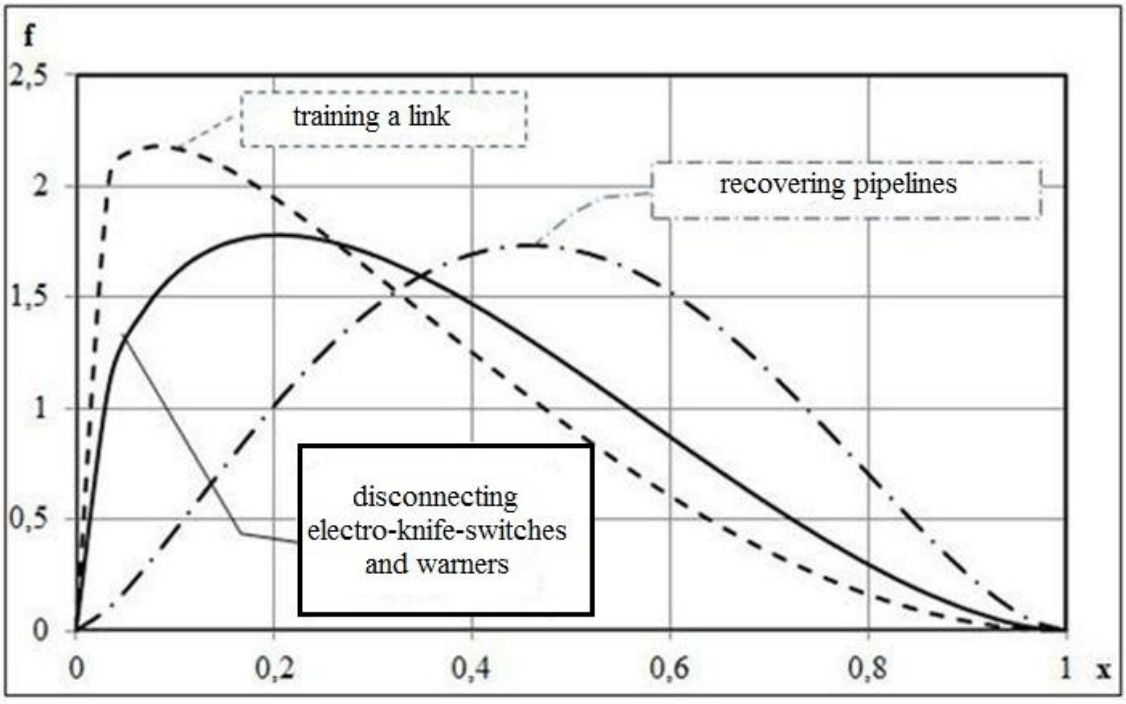
Link	Timing of performing of a stage, s									
	1	2	3	4.11	4.12	5.11	5.12	4.2	5.21	5.22
$\bar{t}$	104,2	17,82	67,64	166,9	219,0	37,25	46,83	202,5	29,23	33,77
σ	31,02	4,91	19,55	73,63	91,12	6,47	8,80	99,05	7,20	10,11
Sk	1,05	0,63	-0,26	-0,05	-0,39	0,22	-0,72	-0,23	0,76	0,75
Ex	1,20	0,17	0,01	-0,52	-0,63	0,35	0,07	-1,05	0,47	-0,23
t_{min}	62,00	10,00	24,00	30,00	25,00	26,00	30,00	25,00	20,00	20,00
t_{max}	205,0	32,00	115,0	300,0	360,0	50,00	60,00	365,0	45,00	53,00
α	1,179	1,444	2,456	1,413	1,482	1,857	1,550	1,073	1,100	
β	2,968	2,732	2,715	1,470	1,144	2,394	1,318	1,030	2,206	

Looked for parameters (table.1) were found by the method of steepest descent [10] by statistical application programs [11]. Estimation of degree of concordance of theoretical and experimental distributions by means of criterion of Kolmogorov K(χ) [12] showed that with a 10% level of meaningfulness it is possible to talk about their convergence. It allows to lean on β-allocation during analysis of received results (except the stage 5.22, distribution timing which has double-humped character).

The analysis of received results shows that typical operations (see a pic. 1) that are not connected with direct performing of rescue works differ in a way that skewed character mostly comes out during training of link in unbreathable area.

$$\beta(x_1; 1{,}179; 2{,}968) = \frac{1}{B(1{,}905; 2{,}686)} \cdot \int_0^{x_1} y^{0{,}179} \cdot (1-y)^{1{,}968} dy, \qquad (8)$$

it can be explained in a way that staff is well trained for performing this operation (practically the same actions are performed by them not rarer than 1 time per a quarter [1]), as a result every link knows his actions very well and also that it is performed on a security post on a fresh air.



Pic. 1. Time allocation (in coding variables) of performing by smoke divers' typical operations not connected with rescue woks

Existing of (4÷6), (8) and also results described in Table.1, allows us taking into account the requirements of frequency and rememberability [13], to offer (supposing by analogy with [14], that an excellent estimation

can get about a 10% of examinee, and good and satisfactory - for 40%) next standards for estimation timing of preparation of Gas rescue service link (putting on special clothing and making operative verification of Respiratory Protective Equipment) during training in smoke and heat training facility

$$t_5(x_1) = 70 \text{ c};\ t_4(x_1) = 95 \text{ c};\ t_3(x_1) = 140 \text{ s}. \qquad (9)$$

Also skewed character have operations that differ from simple typical actions. E.g., disconnecting of disconnecting electro-knife-switches and warners of fire

$$\beta(x_2; 1{,}444; 2{,}732) = \frac{1}{B(1{,}444; 2{,}732)} \cdot \int_0^{x_2} y^{0{,}444} \cdot (1-y)^{1{,}732} dy. \qquad (10)$$

In accordance,

$$t_5(x_2) = 12 \text{ c};\ t_4(x_2) = 17 \text{ c};\ t_3(x_2) = 25 \text{ s}. \qquad (11)$$

But operation of recovering pipelines

$$\beta(x_3; 2{,}456; 2{,}715) = \frac{1}{B(2{,}456; 2{,}715)} \cdot \int_0^{x_3} y^{1{,}456} \cdot (1-y)^{1{,}715} dy, \qquad (12)$$

that requires co-operation between the members of link, who works in a copula, orientation in space and presence of force is already better (with a 5% level of meaning) is described by a normal law

$$f(t_3) = \frac{1}{19{,}55 \cdot \sqrt{2\pi}} \cdot e^{-\frac{(t_3 - 67{,}64)^2}{764{,}41}}. \qquad (13)$$

In this case using (1÷3) and (13),

$$t_5(x_2) = 40 \text{ s};\ t_4(x_2) = 65 \text{ s};\ t_3(x_2) = 90 \text{ s}. \qquad (14)$$

The analysis of operations focused on searching of victim (see pic. 2), shows that time allocation of searching " victim" in a living accommodation

$$\beta(x_{4.2}; 1{,}073; 1{,}030) = \frac{1}{B(1{,}073; 1{,}030)} \cdot \int_0^{x_{4.2}} y^{0{,}073} \cdot (1-y)^{0{,}030} dy \qquad (15)$$

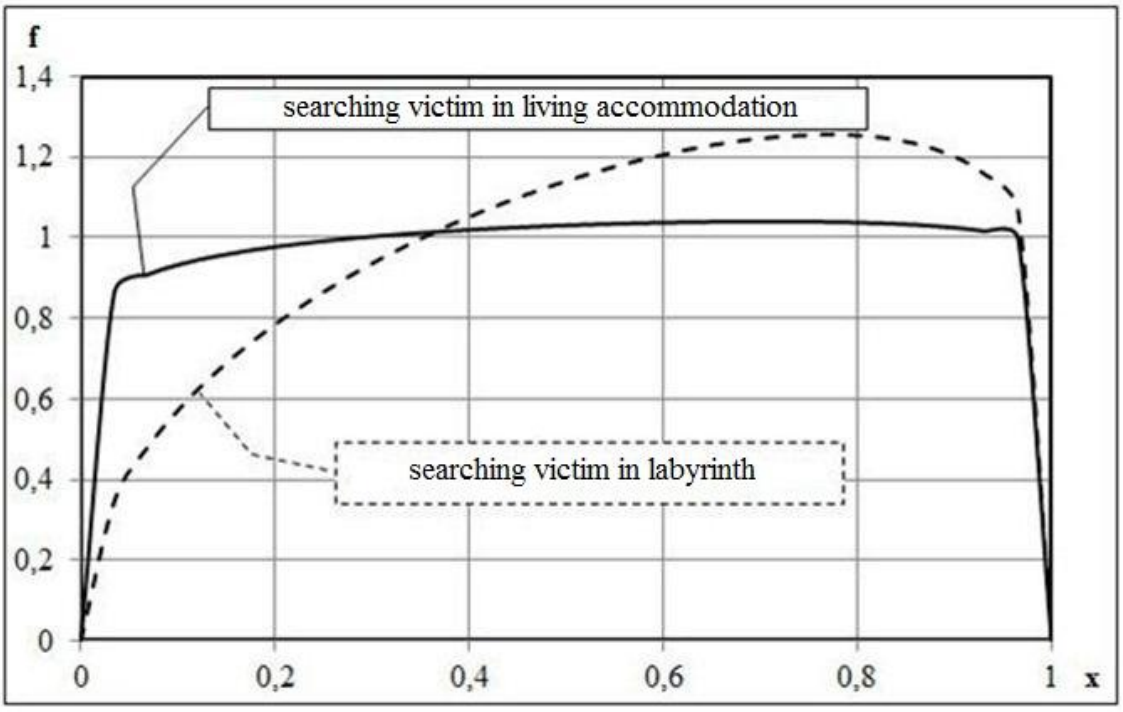
can be examined actually as continuous even, as $\alpha \approx \beta \approx 1$ [15]. It is explained by casual character model placing.

In case of searching " victim" in labyrinth distribution of time probability closeness

$$\beta(x_{4.11};1{,}413;1{,}470)=\frac{1}{B(1{,}413;1{,}470)}\cdot\int_0^{x_{4.11}} y^{0{,}413}\cdot(1-y)^{0{,}470}dy \qquad (16)$$

actually is symmetric relatively $x_{4.11}$=1/2, that it can be explained by casual large enough distance that passes Gas rescue service link, moving to the victim on a labyrinth.

Analysis of (15) and (16) shows that even during smoke divers training it is impossible to set standards in a time for searching victims. Basic attention in this case must be spared to observance of safety and technology of realization of searching works measures in the conditions of absence of visibility [16].



Pic. 2. Time allocation (in coding variables) searching of victims by smoke divers

An analogical situation takes place and in case of performing by smoke divers operations related to evacuation from the useless for breathing environment of victims (see. pic.3 and pic.4). Its analysis shows that psychological factor influences much on character of time allocation.

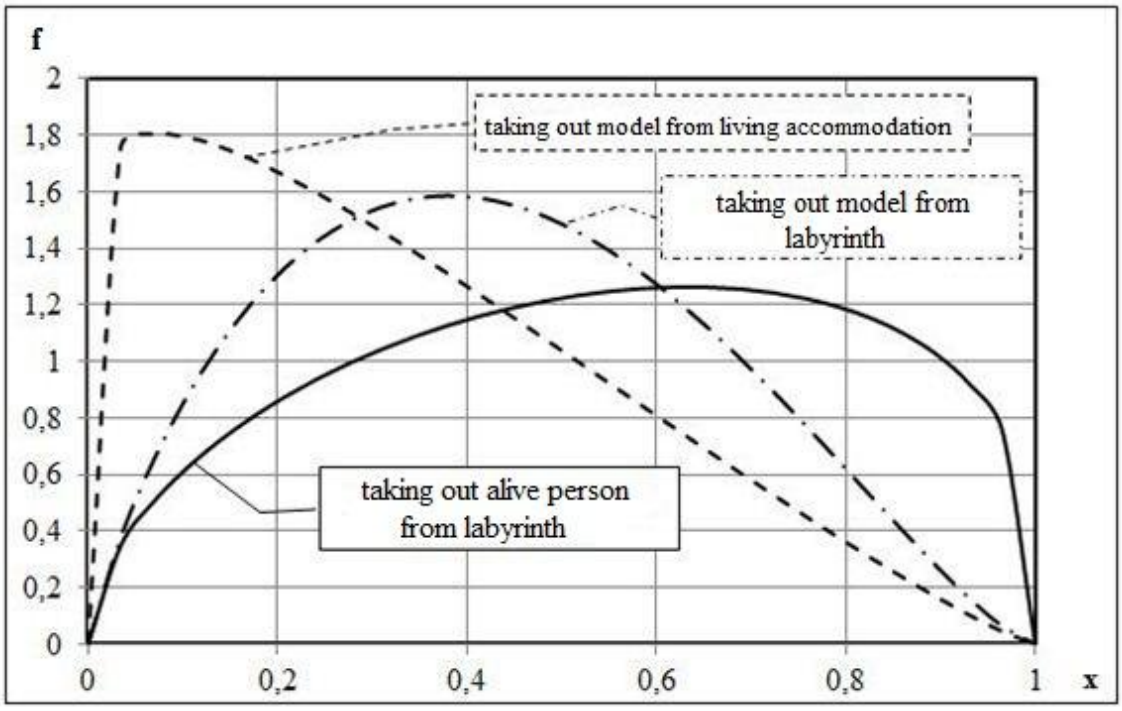
So, as a «victim» is using a model, time allocation for taking him out from living accomodation is

$$\beta(x_{5.21};1{,}100;2{,}206)=\frac{1}{B(1{,}100;2{,}206)}\cdot\int_0^{x_{5.21}} y^{0{,}100}\cdot(1-y)^{1{,}206}dy, \qquad (17)$$

And in a case of taking out from labyrinth

$$\beta(x_{5.11};\,1{,}857;\,2{,}394)=\frac{1}{B(1{,}857;\,2{,}394)}\cdot\int_0^{x_{5.11}} y^{0{,}857}\cdot(1-y)^{1{,}394}\,dy \quad (18)$$

characterized by positive skewed, that can be explained by the good level of endurance of examinee. Thus a higher index in case of taking out "victim" from a living room is because a link returned on fresh air on a that route that he already passed at an entrance, along a sleeve line. During taking out "victim" from labyrinth except endurance additionally an important factor is ability of head of link to orient in space.



Pic. 3. Time allocation taking out victim to fresh air by smoke divers

Analysis (17) and (18), and also terms they were recieved, allow us to offer the next standards related with carrying cargoes from living accomodation and throuht labyrinth in smoke and heat training facility.

$$t_5(x_{5.21})=22\text{ c};\ t_4(x_2)=27\text{ c};\ t_3(x_2)=37\text{s}; \quad (19)$$

$$t_5(x_{5.11})=30\text{ c};\ t_4(x_2)=35\text{ c};\ t_3(x_2)=45\text{s}. \quad (20)$$

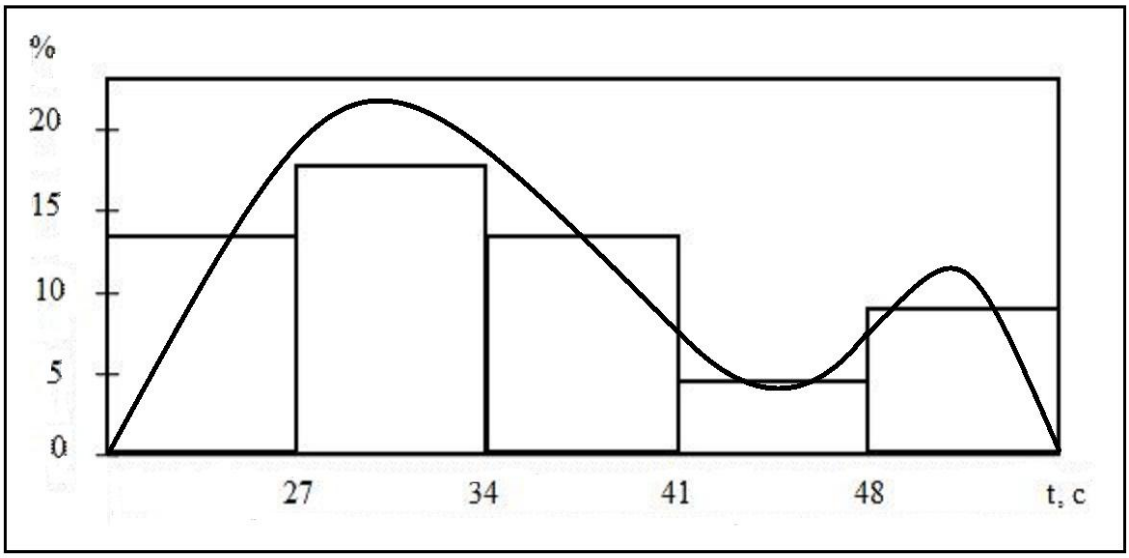
During taking out alive person throuht labyrinth time allocation will be

$$\beta(x_{5.12};\,1{,}550;\,1{,}318)=\frac{1}{B(1{,}550;\,1{,}318)}\cdot\int_0^{x_{5.12}} y^{0{,}550}\cdot(1-y)^{0{,}318}\,dy \quad (21)$$

negative because it can be caused by fear to damage a person that was playing a role of victim, during moving on way where there are plenty of various turns.

Must be marked (see. pic.4) case of taking out alive person by trained smoke divers through very simple route (along a sleeve line, stage 5.22).

You can see that in examined case the extreme situation related to the necessity to warn damage of alive person sometimes sharply worsens the smoke divers results of implementation of such operation (about 10%) at the same time they are well trained for this operation without extreme load.



Pic. 4. Histogram time allocation of taking out alive person by smoke divers to the fresh air

But we can't say that presented at pic.4 double- humped distribution can be examined as a sum of two independent distributions because module of excess ($Ex_{5.22} = -0{,}23$) is less than two [15].

Conclusions*:*

– it is shown that training of smoke divers with using standards for realization for realization of fire – rescue works in a case of fire take place in basements and ground floors it is desirable to perform by Gas rescue service links on fresh air, performing concreate operations not connected with rescue works and also providing taking out material and technical values from unbreathable zone. Taking about smoke and heat training facility where it is performed training of staff in National University of Civil Protection of Ukraine, was described the list of standards;

– it is marked that during smoke divers training the situations related with searching of victims and also taking out them to fresh air special attention must be focused on questions related with observance of safety measures, including in relation to a victim.

REFERENCES

1. Настанова з організації газодимозахисної служби в підрозділах Оперативно-рятувальної служби МНС України : Наказ МНС України № 1342 від 16 грудня 2011р. : М-во надзв. сит. України, 2011. – 56 с. – (Нормативний документ МНС України. Настанова).

2. Дутов В.И.,Чурсин И.Г. Психофизиологические и гигиенитические аспекты деятельности человека при пожаре. – М., Стройиздат, 1993. – 231 с.

3. Самонов А.П. Психологическая подготовка пожарных - М. Стройиздат, 1987. – 167 с.

4. Стрілець В.М. Експертна оцінка психофізіологічних якостей газодимозахисників / В.М. Стрілець, П.А. Ковальов, О.В. Єлізаров // Пожежна безпека. – №2(65) 2005. – С. 24, 25

5. Патент на корисну модель «Димокамера для тренування рятувальників» авторів Безуглов О.Є., Петренко О.В., Бородич П.Ю.

6. Стрелец В.М. Особенности обоснования комплексных нормативов для практических занятий / Стрелец В.М., Ковалев П.А., Нередков Р.А. // Проблеми надзвичайних ситуацій. – № 5 – Харків, Фоліо, 2006. – С. 129-133.

7. Стрелец В.М. Статистический метод обоснования нормативов боевого развертывания пожарно- технического вооружения / Стрелец В.М., Грицай Т.Б. // Право і безпека: Науковий журнал. – 2002. – Вип. 1 – С. 165-171.

8. Стрілець В.М. Розкриття закономірностей виконання газодимозахисниками основних операцій / В.М. Стрілець, П.А. Ковальов, Є.А. Молодика, В.М. Іщук // Вісник Львівського державного університету безпеки життєдіяльності: зб. наук. пр. – 2015. – № 11. – С. 165-172.

9. Стрелец В.М. Уточнение закономерностей деятельности спасателей в процессе подготовки технических средств к применению / В.М. Стрелец, П.А. Ковалев, С.Н. Щербак // Проблеми надзвичайних ситуацій. – 2015. – № 21. – С. 96-106. – Режим доступу: http://nuczu.edu.ua/sciencearchive/ProblemsOfEmergencies/vol21/Strelec.pdf.

10. Аттетков А.В., Галкин С.В., Зарубин В.С. Методы оптимизации: Учеб. для вузов / Под ред. В.С. Зарубина, А.П. Крищенко. – 2-е изд., стереотип. – М.: МГТУ им. Н.Э. Баумана, 2003. – 440 с.

11. Фигурнов С.Н. Microsoft Exel – инструкция пользователю. – Москва, 2003. – 347 с.

12. Митропольский А.К. Техника статистических вычислений – Главная редакция физико-математической литературы издательства "Наука", 1971. – 576 с.

13. Спортивная метрология. Учебник для ин-тов физ. культ. / Под ред. В.М.Зациорского. – М.: ФиС, 1982. – 256 с.

14. Стрелец В.М. Разработка нормативов для оценки подготовленности спасателей к работе в комплексе средств индивидуального типа / В.М. Стрелец, М.В. Васильев, В.В. Тригуб // Проблеми надзвичайних ситуацій. – 2014. – № 19. – С. 133-141. – Режим доступу: http://nuczu.edu.ua/sciencearchive/ProblemsOfEmergencies/vol19/19.pdf

15. Королюк В.С., Портенко Н.И., Скороход А.В., Турбин А.Ф. Справочник по теории вероятностей и математической статистике. – М.: Наука, 1985. – 640 с.

16. Правила безпеки праці в органах і підрозділах МНС : Наказ МНС України № 312 від 7 травня 2007р.: М-во надзв. сит. України, 2007. – 215 с. – (Нормативний документ МНС України. Правила).

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Разработка предложений по подготовке газодымозащитников к проведению пожарно-спасательных работ в подвальных помещениях и цокольных этажах зданий

Предложены рекомендации, включая нормативные показатели, по подготовке газодымозащитников к проведению аварийно-спасательных работ в случае пожара в подвальных помещениях и цокольных этажах зданий. Для их обоснования использовались закономерности выполнения соответствующих операций, полученные в результате статистического анализа результатов физического моделирования деятельности звеньев ГДЗС.

Ключевые слова: газодымозащитники, подвал, закономерности деятельности, закон распределения.

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Розробка пропозицій щодо підготовки газодимозахисників до проведення пожежно-рятувальних робіт в підвальних приміщеннях та цокольних поверхах будівель

Запропоновані рекомендації, включаючи нормативні показники, щодо підготовки газодимозахисників до проведення аварійно-рятувальних робіт у випадку пожежі в підвальних приміщеннях та цокольних поверхах будівель. Для їх обґрунтування використовувались закономірності виконання відповідних операцій, отриманих в результаті статистичного аналізу результатів фізичного моделювання діяльності ланок ГДЗС.

Ключові слова: газодимозахисники, підвал, закономірності діяльності, закон розподілу.