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Methodological aspects of justifying the specialists training duration of the armed forces branches of a formation (unit)

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Abstract. In the study, the duration of training of specialists in the branches of the armed forces of a formation (unit) refers to the amount of training time or the number of training hours required to achieve the required level of training of specialists in the relevant categories (profiles), primarily those that determine the combat capability of the formation (unit).

The current conditions of armed struggle place increased demands on the level of training of troops (forces). At the same time, during a special period, this training can be carried out under conditions of significant resource, including time, constraints, which requires military command and control bodies (commanders) to take a balanced and comprehensively justified approach to planning training and building the training process of troops (forces). Thus, the experience of combat operations once again confirms the need to address one of the most important and problematic issues - to ensure that the amount of training time allocated for the training of specialists in formations (units) and in training centres (schools) meets real needs. Failure to address this issue has a negative impact on the development of the knowledge, skills, physical and psychological qualities required in a combat situation, and thus on the combat capability of the unit.

At present, in units and training centres (schools), the amount of training time required for certain military specialities (positions) is determined mainly based on military experience, by comparing different forms and methods of training, and without the necessary analytical justification. Therefore, the relevance of this study is precisely due to the need to scientifically substantiate the amount of training time that would ensure both the required level of training of specialists in the relevant categories (profiles) and the appropriate level of training and combat capability of units of the branches of the military and the formation (unit) as a whole.

The purpose of the article is to outline the methodological aspects of substantiating the duration of training of specialists in the branches of the military forces of a formation (unit).

With the help of the above methodological aspects, it is possible to analytically express the process of training specialists of any category (profile) through a function of the type, which characterises the dependence of the achieved level of training of these specialists on the number of training hours during which servicemen learn a certain amount of information - acquire the necessary knowledge, skills and abilities. Graphically, the function can be represented as a -shaped curve that characterises the dynamics of the educational process - the initial and main periods of training. Based on the results of the study of the behaviour of the -shaped curve and the position of its inflection point,

the law of change in the level of training (training effectiveness) of specialists of a certain i-th category (profile) is formulated, depending on the number of training hours during which they acquire the necessary knowledge, skills and abilities, and the values of the parameters and, which most appropriately reflect the dynamics of the educational process of specialists of any category (profile). The presented law makes it possible to unambiguously determine the required number of training hours to achieve the desired level of training of specialists in the branches of the military forces of a formation (unit), and the dynamics of its behaviour is like the continuous Weibull-Gnidenko probability distribution.

The materials of the article are of theoretical value for further scientific research on the problem, as well as practical value - aimed at maintaining (developing) the typical group of capabilities FDR-3 (Training of Military Command and Control Bodies and Troops (Forces)). The practical use of the above methodological aspects will contribute to improving the quality of planning and building the process of training troops (forces), and thus to increasing their combat capability and ability to effectively counter the enemy on the battlefield.

Keywords: combat capability; training of troops (forces); individual training; training; knowledge, skills, abilities; military accounting speciality; training planning; structure of the educational process.

Introduction

The basis of the training of troops (forces) is the individual training of servicemen, and the level of training achieved by specialists of the relevant categories (profiles) is a crucial element of the coherence of units, units, and formations. The results of individual training should achieve the main goal of the educational process - the formation of a serviceman as a specialist, the development of knowledge, skills, physical and psychological qualities necessary in a combat situation. It is also important to consider that the process of individual training of personnel is inseparable from the process of combat coordination of squads (crews, services), platoons, companies (batteries), battalions (divisions).

Training is the level of preparation for performing assigned tasks of units, units, formations - one of the main indicators by which their combat capability is assessed - a state that determines the ability of military formations (MF) to implement their combat capabilities, conduct combat operations in any conditions of the situation and perform assigned tasks. At the same time, the effectiveness (level) of combat training of a formation (unit) is assessed by the following indicators: training – the level of individual training of servicemen of all categories; the level of training (cohesion) of command-and-control bodies (headquarters); the level of training (cohesion) of units of a formation (unit).

The rapidity of modern operations (combat actions), the growing capabilities of intelligence and firepower, the increasing role of maneuvers, the safety of the use and protection of troops (forces), the adoption of new models of weapons and military equipment (WME) place increased demands on the level of training of individual servicemen and units. At the same time, in a special period, this training can be carried out under conditions of significant resource, in particular time, constraints, which requires military command and control bodies (commanders) to take a balanced and comprehensively justified approach to planning training and building the training process of troops (forces). Thus, the experience of combat operations once again confirms the need to address one of the most important and problematic issues - to ensure that the amount of training time allocated for training specialists in formations (units) and in training centres (TCs) (schools) meets real needs. Failure to address this issue negatively affects the development of knowledge, skills, physical and psychological qualities required in a combat situation, and thus the combat capability of the unit. Therefore, despite resource constraints, military command and control bodies (commanders) take

certain measures to ensure that the duration of personnel training, primarily in military specialties (MS) (positions) that determine combat capability, is sufficient for successful combat operations. In particular, the long-term domestic and foreign experience of training troops (forces) is considered, which shows that for a serviceman to be able to perform duties in his specialty (position) independently and as part of a crew (service), the unit needs to have a training period of 4 to 6 months. At the same time, the amount of training time should be from 600 to 800 academic hours (6-8 academic hours per day for a 6-day academic week or 156-208 academic hours per month). First, this applies to the positions for which a specialist class qualification is awarded, for example, commanders of combat vehicles (guns), gunner-operators (gunners), driver mechanics (drivers), senior gunners (aimer), anti-aircraft gunners (gunners), etc. It is also considered that a reduction (in a special period) of the overall training period for personnel and an increase in the intensity of the training process - the number of training hours per day (considering the physiological capabilities of a person) - may have a negative impact on the result of training. For example, the experience of training personnel in specialized training centres - "Afghan training schools" for the Soviet troops in Afghanistan (the 40th Combined Arms Army) - is important. Thus, since 1982, training in the "sergeant's school" has lasted five to five and a half months (about 780-860 training hours), while in the "soldier's school" - two months (about 312-416 training hours). By the spring of 1984, it became clear that a two-month training period for "soldier's training", even with a rich curriculum, was not enough. It was decided to extend the training period up to 3 months (468-624 training hours) for personnel trained in the "rifleman" specialty. For servicemen who were assigned to more complex military specialties, such as gunner-operator, tank gunner (loader), machine gunner, gunner, gunner's number, driver, grenade launcher, etc., the training period was extended to five months (800 training hours). Since May 1985, all new recruits to the 40th Army have been trained under a five-month program.

At present, in units (units), in educational centres (schools), the amount of training time required for certain military occupational specialties (positions) is determined mainly on the basis of military experience, by comparing different forms and methods of training and without the necessary analytical justification. Therefore, the relevance of this study is due to the need to scientifically substantiate the amount of training time that would ensure the required level of training (proficiency) of both specialists of the relevant categories (profile) and units of the branches of the armed forces and formations (units) in general.

The purpose of the article is to outline the methodological aspects of substantiating the duration of training for specialists of the branches of the military in a formation (unit).

Methodological Framework

The proposed methodological aspects make it possible to analytically express the process of training specialists of a certain category (profile) through a type function $E(x)$, that characterizes the dependence of the achieved level of training E of these specialists on the number of training hours x during which servicemen learn a certain amount of information - acquire the necessary knowledge, skills and abilities. The function $E(x)$ is a display for which the scope of the definition of this function - the set x - the number of training hours from 0 to the planned $x_{план} \approx 600 - 800 \approx$ 700 hours $(0 \le x \le x_{план})$ ones is matched, the set of function values - the numerical range $(0 \le E(x) \le 1)$ - all the function values $E(x)$ from 0 to 1, - the achieved level of training of specialists of a certain category, where the argument is the number x of study hours. It is believed that the process of training specialists of any category is continuous, and its dynamics are similar in content. Conventionally, the educational process can be divided into two periods: initial - mainly theoretical training and main - during which the practical component of training for a certain MS (position) dominates.

Graphically, the function $E(x)$ can have the form of a S -like curve with asymmetric branches,

and therefore there must be a special point - an inflection point with abscissa x_1 dividing this curve into two parts - concave (initial period of preparation) and convex (main period of preparation) (Fig. 1).

The transition from the concave part of the *S*-shaped function $E(x)$ curve to the convex part is a sufficient condition for the existence of a certain inflection point. The presence of an inflection points in the behaviour of the function $E(x)$ in this case qualitatively reflects (underlines) the dynamics of the educational process, and its position will be determined by a specific type of function $E(x)$ that describes the educational process in one or another specialty.

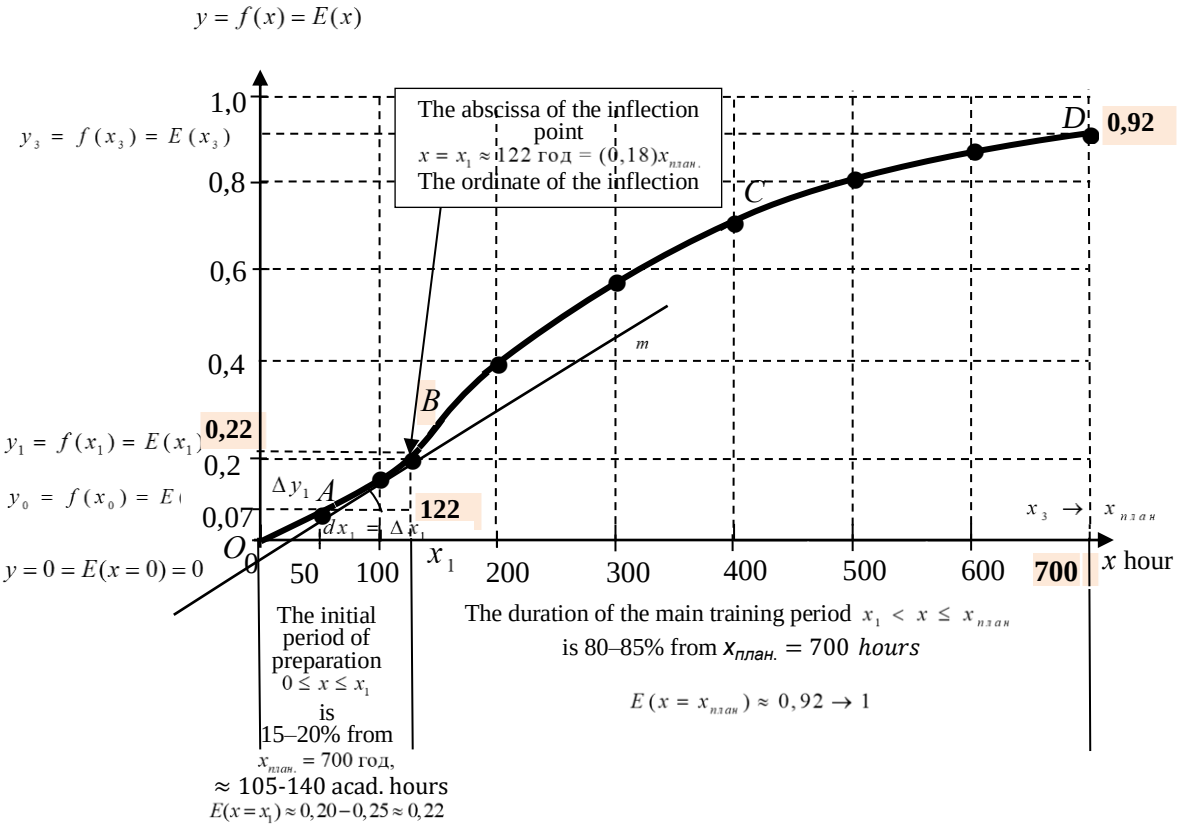


Figure 1. A possible graph of the function $y = f(x) = E(x)$

On the example of the training of specialists (sergeants, soldiers) of the main units (mechanized, tank, artillery, anti-aircraft) of a separate mechanized brigade (unit) in national centres (schools) and directly in compounds (units), we will consider the dynamics of their educational process (behaviour of a S -like curve), namely: the dependence of the achieved level of training $E(x)$ of these specialists on the number of training hours (x) planned for a certain period of training. In accordance with the requirements of the governing documents, the general level of training and overall combat capability of the armed forces is assessed based on the level of training of these specialists (units) of the military branches.

S -like curve $E(x)$ reflects two main periods of the educational process. Each of these periods corresponds to its own dynamics of behaviour S -like curve similar to that in fig. 1 is conventionally shown by currents *O, A, B, C, D.*

The first training period (initial)

At the beginning of the educational process S-like curve $E(x)$ starts from point O with coordinates $x=0$, $E(x=0)=0$ – the initial training period begins with a duration $x=0\le x\le x_1$, of 15–20% of the planned $x=x_{план.}\approx 700$ hours, or $x=x_1=105-140$ hours. Military servicemen get acquainted with the future specialty, they develop the necessary theoretical knowledge, practical skills, and primary skills. The curve is slowly but gradually increasing. In fig. 1 the initial period of training is reflected by the concave part of the S-like curve $E(x)$. During this period, about 80% of the amount of training time is devoted to theoretical classes in the specialty, and the achieved level of training will correspond to the value $E(x=x_1)\approx(0,20-0,25)$, which is assumed to be approximately the same for specialists of any profile. At a certain point in time, the level of training of military personnel allows you to move to the second, main, period of training, during which the personnel acquire the necessary practical skills and skills for the corresponding MS (position). The level of learning achieved during the initial training period $E(x_1)$ is limited by the inflection point *B*, which separates the concave part of the S-like curve from the convex part. If we take the average value of the abscissa of the inflection point *B* $x=x_1\approx 122$ hours $=0,18$, and the corresponding average value of its ordinate, $E(x=x_1\approx 122$ hours$)\approx 0,22$, then the second (main) period of preparation begins from this moment.

Second training period (main)

After the inflection point *B* the training process is intensified, the main period of training of military personnel in accordance with the MS (positions) with a duration of $o\le x\le x_1$. A gradual build-up of the necessary practical skills and skills in the personnel is observed. S - like curve grows more rapidly and passes, for example, through point *C*. The duration of the main training period is about (80–85%) $x_{план.}$, i.e. $(x_1\approx(0,15-0,20)<x\approx(0,80-0,85)\le x_{план}\to 1)$, at the same time, the level of achieved education is $E(x=x_{осн})\to E_{потр}$.. About 80% of the training time of this period is devoted to conducting practical classes in the specialty. At the end of the main period of training there is some slowing down of the pace of the educational process and assimilation of the educational material by military personnel, the curve becomes gentler. The dynamics of increasing the level of training of specialists is somewhat slowing down. In fig. 1, the slowing down of the educational process and its end is characterized by point *D* with coordinates $x\to x_{план}$, $E(x_3)\to E(x_{потр})\to 1$ $(e^{-\lambda\cdot x^{\kappa}}\to 0)$.

Since the process of training specialists of different categories is continuous, the function $y=f(x)=E(x)$, which graphically displays the educational process in the form of a S-like curve, is continuous, and it must be differentiated twice. If the function $E(x)$ is differentiable, that is, it has a derivative at every point of some interval *OD*, then the function is differentiable on this interval. If the derivative of the first order at each point S-like curve characterizes the speed with which the function $E(x)$ changes, then in order to find the position - the coordinates $(x_1;\ y_1)$ of the inflection point B, it is necessary and sufficient to find the second derivative at this point and equate it to 0. The derivative of the second order at the inflection point $B(x_1;\ y_1)$ characterizes the acceleration of the level of learning $E(x)$ of the individual achieved at a certain time composition or the rate at which the rate of growth of this level of learning changes relative to time. The acceleration determined by the inflection point characterizes the transition to the main training period, which is indicated by the convex part of the S-like curve. The convexity of the curve indicates that the second derivative of the function $E(x)$ at the inflection point is positive (>0), the tangent at this point passes through quadrants 1 and 3, and the tangent of its slope angle is positive, which indicates a transition to the convex part of the *S*-like curve.

Dependence, when the S-like graph corresponds to the functional dependence $E(x)$, is displayed analytically similar to the continuous Weibull-Hnidenko probability distribution. The Weibull-Hnidenko continuous probability distribution function is two-parametric and has the form:

$$E(x) = 1 - e^{-\lambda \cdot x^{\kappa}}, \quad (1)$$

where $x \geq 0$; $\lambda > 0$ is the first parameter of the distribution – some constant, scale factor (scale of distribution), which characterizes the intensity of the distribution and affects the shape of the curve $E(x)$. The larger the scale factor, the more widespread the distribution. The parameter λ is a dimensionless value. In the study, the physical content of this coefficient can characterize the amount of information learned by military personnel per unit of time (for example, for 1 training hour) or for a specified (on the abscissa) number of training hours. The value of this coefficient depends on the general educational level of personnel training, training in the amount of the general military minimum, the previously achieved level of training, the state and order of use of the educational material and technical base, etc.; $\kappa > 0$ - the second parameter of the distribution is the shape coefficient, the exponent (integer or fractional), which determines the shape of the graph. In the study, the physical meaning of this coefficient can characterize the growth of the level of education per unit of time. The type of Weibull-Hnidenko continuous probability distribution function depends on the value of the coefficient κ. For example, for a $\kappa = 1$ continuous probability distribution, the Weibull-Hnidenko coincides with the exponential one; for $\kappa = 2$ – turns into a Rayleigh distribution; for $\kappa > 3,5$ – practically coincides with the normal distribution law (Gaussian). The parameter κ, like λ, is a dimensionless value.

Acceptable parameter values κ and λ were determined in the study to emphasize the peculiarities of the behaviour of the function $E(x)$. In particular, the influence of parameters κ and λ on the position of the inflection point and on the behaviour of the S-like curve at the inflection point was investigated. To find the coordinates (abscissa $x = x_1$ and ordinate $y_1 = E(x_1)$) of the inflection point of the *S*-like curve, it is necessary and sufficient to find the second derivative of the function at the inflection point and equate it to 0. Thanks to the calculation of the second-order derivative $(\frac{d^2E(x)}{dx^2} = 0)$, the expression is obtained:

$$x^{\kappa} = \frac{\kappa - 1}{\kappa \cdot \lambda}, \quad (2)$$

from where the abscissa of the inflection point is determined by the values κ and λ:

$$x = x_1 = \kappa\sqrt{\frac{\kappa - 1}{\kappa \cdot \lambda}} = \left(\frac{\kappa - 1}{\kappa - \lambda}\right)^{\frac{1}{\kappa}}, \quad (3)$$

and the ordinate of the function $E(x)$ at the inflection point, considering (2), will be calculated as:

$$E(x = x_1) = 1 - e^{-\lambda \cdot x^{\kappa}} = 1 - e^{-\lambda \cdot \frac{\kappa - 1}{\kappa \cdot \lambda}} = 1 - e^{-\frac{\kappa - 1}{\kappa}}, \quad (4)$$

and does not depend on the value of the parameter λ, but is determined only by the value of κ.

The functional dependence (1) can be expressed as:

$$E(x) = 1 - e^{-\lambda \cdot x^{\kappa}} \geq E(x)_{nomp}. \quad (5)$$

From (5), necessary for achieving $E(x)$ the required number of training hours x can be determined as follows:

$$e^{-\lambda \cdot x^{\kappa}} = 1 - E(x); \qquad \ln e^{-\lambda \cdot x^{\kappa}} = \left[\ln\left(1 - E(x)\right)\right]; \qquad -\lambda \cdot x^{\kappa} = \left[\ln\left(1 - E(x)\right)\right];$$

$$x^{\kappa} = -\frac{\left[\ln\left(1-E(x)\right)\right]}{\lambda}; \qquad x = \left[-\frac{\ln\left(1-E(x)\right)}{\lambda}\right]^{\frac{1}{\kappa}},$$

if $E(x) = E_{потр}$, then:

$$x \geq x_{план.} = \left[-\frac{\ln\left(1-E_{потр}\right)}{\lambda}\right]^{\frac{1}{\kappa}} \quad (6)$$

By condition, the number of training hours allocated for the training of military personnel in one or another specialty is taken at the level $x = x_{план} = 700$ hours per training period. Thus (6) can be written as:

$$x = x_{план} = 700 \geq \left[\frac{\ln\left(1-E_{потр}\right)}{\lambda}\right]^{\frac{1}{\kappa}}, \quad (7)$$

from where the function $E(x)$ (1) parameter λ can be determined:

$$\lambda \geq -\frac{\ln\left(1-E_{потр}\right)}{700^{\kappa}}. \quad (8)$$

From equations (2), (3), considering x_1 (the abscissa of the inflection point), the parameter λ is calculated:

$$\lambda = \frac{\kappa-1}{\kappa \cdot x_1^{\kappa}}. \quad (9)$$

Combining equations (8), (9), we get the transcendental equation:

$$\frac{\kappa-1}{\kappa \cdot x_1^{\kappa}} = -\frac{\ln\left(1-E_{потр}\right)}{700^{\kappa}}, \quad (10)$$

from where the value of the parameter κ can be determined.

If the abscissa of the inflection point is $x = x_1 \approx 122$ год, we will receive:

$$\frac{700^{\kappa}}{122^{\kappa}} = \frac{700^{\kappa}}{\kappa \cdot 122^{\kappa}} - \ln\left(1-E_{потр}\right) \cdot \quad (11)$$

The transcendental equation (11) with respect to the value κ is solved graphically or numerically. To solve it graphically, the transcendental equation (11) can be written in the form of equations that are expressed through the same function y:

$$y = \frac{700^{\kappa}}{122^{\kappa}}; \qquad y = \frac{700^{\kappa}}{\kappa \cdot 122^{\kappa}} - \ln\left(1-E_{потр}\right); \quad (12)$$

the joint solution of these equations graphically will allow to determine the value κ by calculating the values of y given in the table. 1 and 2.

Table 1. Calculation of values $y = \frac{700^{\kappa}}{122^{\kappa}}$

Possible values κ						
1	1,2	1,3	**1,4**	1,6	1,8	**2**
Calculated values y						
5,74	8,13	9,68	**11,55**	16,36	23,21	**32,92**

Table 2. Calculation of values $y = \frac{700^{\kappa}}{\kappa \cdot 122^{\kappa}} - \ln(1 - E_{потр})$

Possible values $E_{потр}$	Possible values κ						
	1	1,2	1,3	1,4	1,6	1,8	**2**
	Calculated values y						
0	5,74	6,78	7,45	8,25	10,23	12,89	16,46
0,2	5,96	7,00	7,67	8,47	10,45	13,11	16.68
0,4	6.25	7,29	7,96	8,76	10,74	13,40	16,97
0,6	6,66	7,70	8,37	9,17	11,15	13,81	17,38
0,8	7,35	8,39	9,06	9,86	11,84	14,50	18,07
0,95	8,74	9,78	10,45	11,25	13,23	15,89	**19,46**

An approximate value is determined from the intersection of the curves $y = \frac{700^{\kappa}}{122^{\kappa}}$ and $y = \frac{700^{\kappa}}{\kappa \cdot 122^{\kappa}} - \ln(1 - E_{потр})$, for example, by $E_{потр} = 0,95$:

$$\kappa \approx 1,3. \quad (13)$$

If we take the average value of the abscissa of the inflection point corresponding to and the corresponding average value of the ordinate of the inflection point $x = x_1 \approx 122 \text{ год} = 0,18$, then the function (4) or the ordinate of the inflection point can be written as a function $E(x = x_1) = 1 - e^{-\frac{\kappa - 1}{\kappa}} = 0,22$, from where more accurate compared to (13) the value of the parameter (exponent of the degree) of the function (1) will correspond:

$$\kappa \approx 1,33. \quad (14)$$

Then, taking into account (3), (9), if $x = x_1 = (\frac{\kappa - 1}{\kappa - \lambda})^{\frac{1}{\kappa}} \approx 122 \text{ год}$, and $\kappa \approx 1,33$ we get the second parameter of function (1):

$$\lambda = \frac{\kappa - 1}{\kappa \cdot x_1^{\kappa}} = \frac{1,33 - 1}{1,33 \cdot 122^{\kappa}} = 0,00042. \quad (15)$$

For a more in-depth analysis of the behaviour of function (1) for different values of quantities x within, for example, 0 ÷ 700 hours and the found values κ = 1.33, λ = 0.00042, the values of this function are calculated (Table 3).

Table 3. Calculation of function values $E(x) = 1 - e^{-\lambda \cdot x^{\kappa}}$

Possible values x (hours)														
0	50	100	**122**	150	200	250	300	350	400	500	550	600	650	**700**
Calculated values $E(x) = 1 - e^{-\lambda \cdot x^{\kappa}}$														
0	0,07	0,17	**0,22**	0,28	0,38	0,48	0,56	0,64	0,70	0,80	0,84	0,88	0,90	**0,92**

Considering the value of table. 3, it can be assumed that the function $E(x)$ (1) satisfies the requirements for the parameters of the educational process and with the same values for all specialties κ = 1.33 (3), (14), λ = 0.00042 (8), (15) acquires, unlike from (1), of the form:

$$E(x) = 1 - e^{-\lambda \cdot x^{\kappa}} = 1 - e^{-0,00042 \cdot x^{1,33}}. \quad (16)$$

For different values κ, λ, the behaviour of the function $E(x) = 1 - e^{-\lambda \cdot x^{\kappa}}$ for $x = x_{план} =$ 700 hours is presented in the table. 4 and Fig. 2.

Conclusions about the parameter λ

From fig. 2 and (3). , that is, as κ the parameter λ (8), (9), (15) (increasing the amount of

information successfully learned per unit of time) decreasing the value of abscissa $x = x_1$ of the inflection point (3), there is a shift of the inflection point and the curves to the left, i.e., as the parameter λ increases, the graph of function (1) (curves) shifts to the left to the ordinate axis, which is normal. And vice versa, from fig. 2 and (3) it follows that for a given κ parameter with decreasing the parameter λ (i.e. decreasing the amount of successfully assimilated information per unit of time) value of the abscissa $x = x_1$ increases of the inflection point (3), the inflection point and curves $E(x)$ shift to the right, i.e., as the parameter λ decreases, the graph of the function (curves) shifts to the right of the ordinate axis. At the same time, the number of training hours required for the training of military personnel x needs to be increased (which may indicate an insufficient level of personnel training). So, the parameter λ characterizes the displacement of the abscissa $x = x_1$ of the inflection point (horizontally – to the left or right) and determines the value of the abscissa of the inflection point at an unchanged value of its ordinate. Thus, with a change in the parameter λ, and therefore with a change in the abscissa of the inflection point $x = x_1 \approx 122$ hours $\approx 0{,}18$, for one and the same κ value, the values of the function $E(x = x_1)$ at the inflection point remain unchanged (4), since they are determined only by the values $\kappa \geq 1$ and do not depend on the parameter $\lambda > 0$. And of the ordinate of the inflection point, that is, the achievable the level of training $y_1 = f(x_1) = E(x_1)$ of specialists in the initial period of training (4) depending on the number of training hours x, is determined by the value of the parameter x.

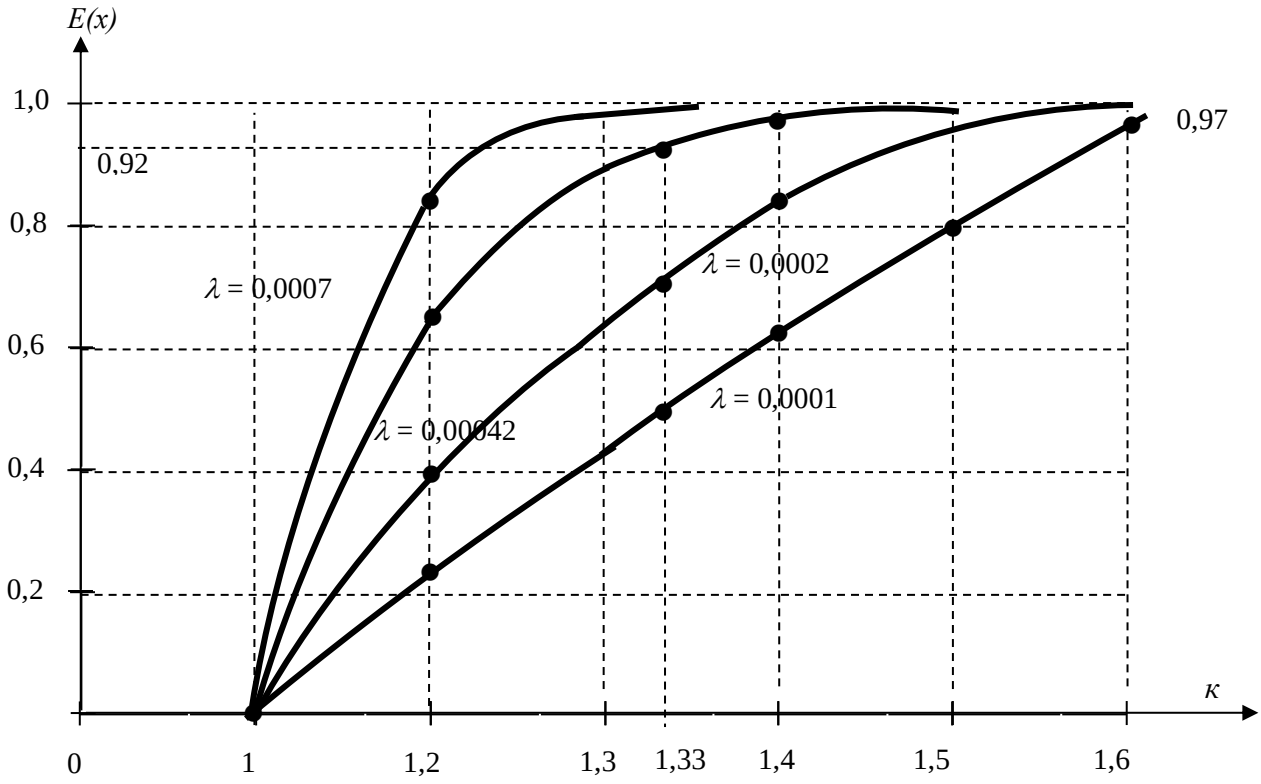


Figure 2. Behaviour of the function $E(x) = 1 - e^{-\lambda \cdot x^{\kappa}}$ at different values κ, λ, for $x = x_{план} = 700$ год

Table 4. Function behaviour $E(x)=1-e^{-\lambda \cdot x^{\kappa}}$ for $x = x_{план} = 700$ год

Possible values κ	Possible values λ						
	0,0001	**0,0002**	0,0003	**0,00042**	0,0005	0,0006	**0,0007**
	Calculated values $E(x)=1-e^{-\lambda \cdot x^{\kappa}}$						
1,0	≈ 0	≈ 0	≈ 0	≈ 0	≈ 0	≈ 0	≈ 0
1,2	0,23	0,40	0,54	0,66	0,73	0,79	0,84
1,33	**0,46**	**0,70**	0,84	**0,92**	0,95	0,97	**0,99**
1,4	0,62	0,85	0,94	0,98	0,99	0,999	≈ 1
1,6	0,97	≈ 1	≈ 1	≈ 1	≈ 1	≈ 1	≈ 1

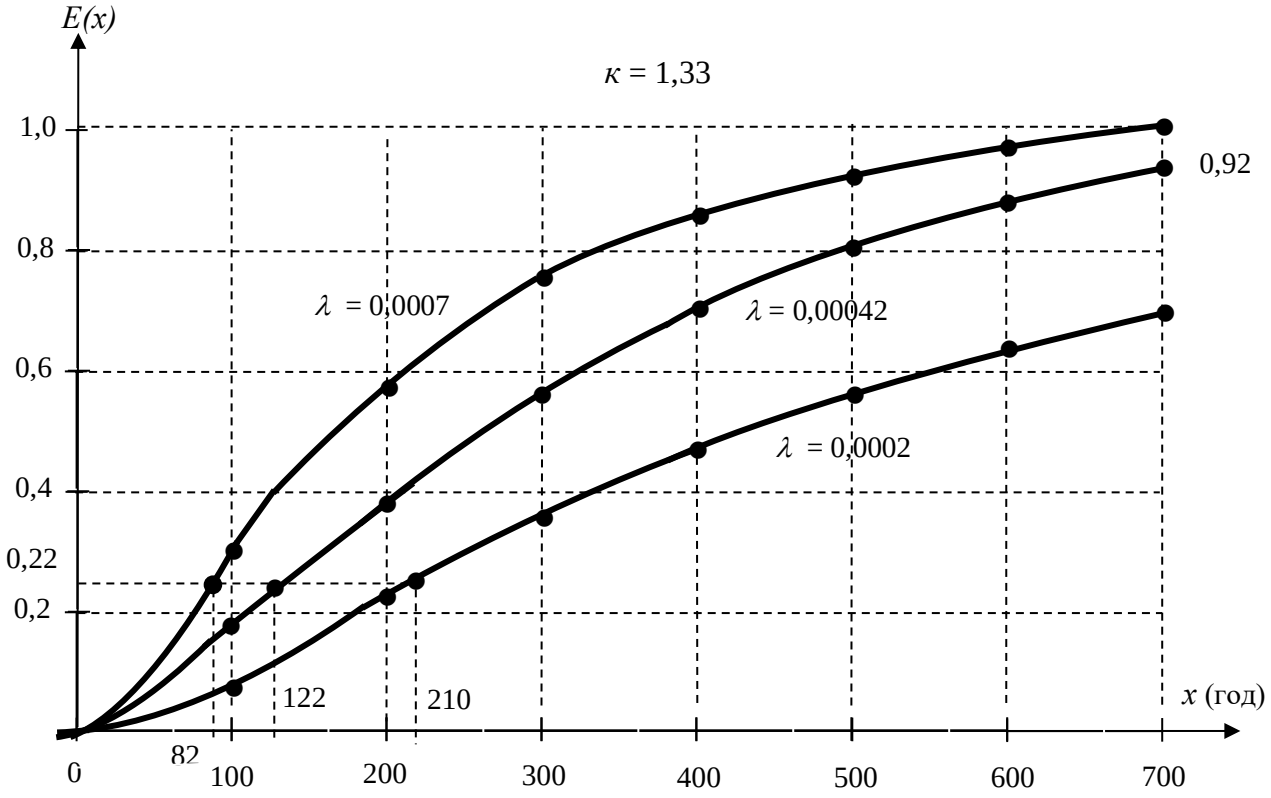


Figure 3. Graphs $E(x)=1-e^{-\lambda \cdot x^{1,33}}$ за $\lambda =$ 0,0002, 0,00042, 0,0007

A decrease in the duration of the initial training period (3) with an increase in parameter λ (9) can characterize (underline) the influence of the general educational level of training or training in the amount of the combined military minimum, which is observed in the personnel before the beginning of the training process, and also allows determining the duration of the initial training period $x = 0 \le x \le x_1$. In fig. 3 according to data, for example, table. 4, graphs of the behaviour of the function $E(x)=1-e^{-\lambda \cdot x^{\kappa}}$ for $x = x_{план} = 700$ год, for different parameter values κ, λ,, in particular for $\lambda = 0.0002, 0.00042, 0.0007$, are shown. In fig. it can be seen that as parameters λ (8), (15) increase, the value (abscissa) of x_1 the inflection point decreases, this point shifts to the left, the curves $E(x)$ shift to the left to the ordinate axis. In the case of a change in the position of the inflection point x_1 and for the same value κ, the values of the function $E(x = x_1)$ at the inflection point remain

unchanged (4), since they are determined only by values $\kappa \geq 1$ and do not depend on the parameter $\lambda > 0$. If, according to the experience of military training, the duration of the initial period of training $x = 0 \leq x \leq x_1$ is 105–140 academic hours, and the average value of the abscissa x_1 of the inflection point corresponds to $x = x_1 \approx 122$ год $\approx 0{,}18$, the corresponding average value of the ordinate of the inflection point will correspond to the achieved level of education $E(x = x_1 \approx 122 \text{ год}) = 0{,}22$, which is assumed to be approximately the same for specialists of any profile.

Conclusions about the parameter κ

The selected value of the parameter κ affects the position of the inflection point, i.e. determines its ordinate or the achievable level of education of specialists $E(x)$ of a certain category in the initial period of their training (4) depending on the number x_1 of training hours during which the information was learned. So, the value of the parameter κ characterizes the movement of the inflection point along the ordinate axis (vertically) and determines the value of the ordinate $y_1 = f(x_1) = E(x_1)$ of the inflection point. As the parameter κ increases, the value of the ordinate of the inflection point increases, and the value of the achieved level of learning (4) at the inflection point increases. As the parameter κ decreases, the value of the ordinate of the inflection point decreases, and the value of the achieved level of learning (4) at the inflection point decreases. The above confirms the presence of an inflection point in the *S*-like curve, as well as the fact that at the inflection point the level of training $E(x = x_1) = 1 - e^{-\frac{\kappa - 1}{\kappa}}$ of military personnel does not depend on the value of the parameter λ, but is determined only by the value of the exponent κ. Considering the fact that the value $E(x = x_1)$ at the inflection point is determined only by the value κ, and the initial period of training and the corresponding level of education are approximately the same for specialists of any i-th category, the results of the calculations made it possible to obtain the values of the parameters $\kappa \approx 1.33$ and $\lambda = 0,\ 00042$, which most appropriately ($x = x_1 \approx 122$ год $= 0{,}18$ – abscissa and $E(x = x_1) \approx 0{,}22$ – ordinate of the inflection point) characterize the behaviour of a S-like curve, which is presented in the form of a function $E(x)$ with a variable x and reflects the dynamics of the educational process of these specialists. Therefore, the coordinates of the inflection point coincide with the data of the initial training period. Thus, the function of changing the level of education of specialists of a certain category (profile) depending on the number x of training hours during which they learn a certain amount of information, for different values of the abscissa of the inflection point x_1, and therefore, for different values of parameter λ (8), (15), unlike from $E(x) = 1 - e^{-\lambda \cdot x^{\kappa}}$, should be written as $E(x_i) = 1 - e^{-\lambda_i \cdot x_i^{\kappa}}$, where λ_i is the parameter of the function $E(x_i)$ for the corresponding i-th specialty ($i = \overline{1,\ 4}$) (the main branches of troops (units)).

The results of the analysis of the behaviour of the curve $E(x)$, shown in fig. 2, as well as in table. 4, allow us to conclude that the obtained parameters $\kappa \approx 1.33$, $\lambda_i = 0.00042$ most appropriately reflect the dynamics of the educational process of specialists of any category (profile). This makes it possible to formulate the law of changes in the level of training (effectiveness of training) $E(x_i)$ of specialists of the i-th category (profile) depending on the number x_i of training hours during which they acquire the necessary knowledge, abilities and skills, and the parameter values $\kappa \approx 1.33$, $\lambda_i = 0.00042$, which are the most adequately reflect the dynamics of the educational process of specialists of any category (profile).

Unlike (16), this law can be written as:

$$E(x_i) = 1 - e^{-\lambda_i \cdot x_i^{\kappa}} = 1 - e^{-0{,}00042 \cdot x_i^{1{,}33}}, \quad (17)$$

where λ_i is the parameter of $E(x_i)$, which in this case, like the parameter κ, is assumed to be the same for any i-th specialty $(i = \overline{1,\ 4})$. Such a law meets the requirements for the function $E(x_i)$, and the dynamics of its behaviour does not differ from the continuous Weibull-Hnidenko probability distribution (16). Therefore, the number x_i of training hours required for achievement $E(x_i)$ can be determined as follows:

$$e^{-\lambda_i \cdot x_i^{\kappa}} = 1 - E(x_i); \qquad \ln e^{-\lambda_i \cdot x_i^{\kappa}} = \left[\ln\left(1 - E(x_i)\right)\right]; \qquad -\lambda_i \cdot x_i^{\kappa} = \left[\ln\left(1 - E(x_i)\right)\right];$$

$$x_i^{\kappa} = -\frac{\left[\ln\left(1 - E(x_i)\right)\right]}{\lambda_i}; \qquad x_i = \left[-\frac{\ln\left(1 - E(x_i)\right)}{\lambda_i}\right]^{\frac{1}{\kappa}},$$

if marked $E(x_i) = E_i$, we will write it down as:

$$x_i \geq x_{i\,план} = \left[-\frac{\ln(1 - E_i)}{\lambda_i}\right]^{\frac{1}{\kappa}}. \quad (18)$$

Results

According to (17), (18) it is possible to calculate the number of training hours x_i that will allow to achieve the required level of training $E(x_i)$ of specialists of any i-th category (profile). For example, for the given value $E(x_i) = E_i = 0{,}9$ of κ = 1,33, λ = 0,00042, the number of training hours required for training the i-th category of specialists will be calculated as follows:

$$x_i = \left[-\frac{\ln(1 - E_i)}{\lambda_i}\right]^{\frac{1}{\kappa}} = \left[-\frac{\ln(1 - 0{,}9)}{0{,}00042}\right]^{\frac{1}{1{,}3}} = \left[-\frac{\ln 0{,}1}{0{,}00042}\right]^{0{,}752} = \left[-\frac{2{,}30258}{0{,}00042}\right]^{0{,}752} = 5483^{0{,}752} = 648 \text{ год.}$$

Given the given value $E(x_i) = E_i = 0{,}85$ of κ = 1,33, λ = 0,00042, the number of training hours x_i required for training the i-th category of specialists will be calculated as follows:

$$x_i = \left[-\frac{\ln(1 - E_i)}{\lambda_i}\right]^{\frac{1}{\kappa}} = \left[-\frac{\ln(1 - 0{,}85)}{0{,}00042}\right]^{\frac{1}{1{,}3}} = \left[-\frac{\ln 0{,}15}{0{,}00042}\right]^{0{,}752} = 560 \text{ год.}$$

The calculated learning time resource is within the planned limits.

Discussions

The study of problematic issues related to the training of troops (forces) and the development of scientifically based recommendations on ways to solve them is an important component of the development of the theory of military training and education as a branch of military science, as well as one of the main tasks of scientific (research) institutions and military command and control bodies of the Armed Forces of Ukraine.

At the same time, the results of the analysis of recent publications in the field of research, in particular, existing methods for assessing the level of training of specialists (units) of branches of the armed forces, formations (units) and justification of the amount of training time required for their training (Nesterov A. G., 2001; Malkov M. I., 2001; Pichugin M. F., 2002; Gorda M. Y., Zhernakov Y. V., 2004; Molokov O. V., 2005; Chabanenko P. P., 2012; Sidash V. V., 2013; Kovch V. Yu, 2020; Sakovskyi H.

A., 2020; Tymkiv O. A., 2021; Pekhota S. G., 2021; Zaluzhnyi V. F., Moisiuk E. G., Shaptala S. O., 2022; Zaluzhnyi V. F., Zabrodskyi M. V., 2023; Chornomaz O. O., 2023), allow us to draw the following conclusions:

– in the work of command-and-control bodies (headquarters), empirical models are usually used in planning training and building the educational process of troops (forces), which are reflected in planning and policy documents, methods and training programs. However, these models do not always accurately reflect the dynamics of the educational process, in particular, the dependence of the achieved level of training of specialists (units) of the branches of the armed forces on the number of training hours allocated for their training (Godz S.V., 2021), (Mozharovskyi, V. M., Godz, S. V., Sakovskyi, H. A., 2019);

– most of the papers combine deterministic and stochastic models. For example, (Malkov, M. I., 2001) describes a methodology for assessing the effectiveness of the combat training system of combined arms formations (units) of permanent readiness; (Sidash, V. V., 2013) – an improved methodology for planning flight training of aviation brigade crews, taking into account resource constraints and opportunities for implementing planned activities; (Molokov, O. V., 2005) – a methodology for assessing the effectiveness of individual fire training of personnel of the Armed Forces units; (Harabara, V. I., 2020) – an improved comprehensive methodology for assessing the effectiveness of combat training of a tank brigade during the resumption of combat;

– a number of papers use the exponential distribution of the level of training over time ((Pichuhin M. F., 2002) – substantiation of recommendations for improving the training system for junior specialists for anti-aircraft missile forces in the NC; (Hrom, V. A., 2017) – improved methodology for assessing the effectiveness of combat training of units and subunits of engineering troops);

– in some works, in particular (Dyenyezhkin, M. M., 2019) – (Mozharovskyi, V. M., 2018), indicators are used to assess the combat capability of the MF, which characterize their staffing, provision of basic types of anti-aircraft weapons and expendable logistic support. At the same time, the indicators characterizing the level of training of the personnel and the military personnel and MF are not taken into account or are taken into account as limitations;

– there are studies, in particular (Tymkiv, O. A., 2021), (Zaluzhnyi, V. F.), which highlight the experience of combat operations and raise problematic issues of training personnel, units, and units in the context of repelling the armed aggression of the Russian Federation against Ukraine. These works are important for further study of the issues of training of the Armed Forces and the Defence Forces in general.

At the same time, in the presented methods for evaluating the level of training of personnel and MF indicators of time costs (required number of training hours) are chosen mainly on the basis of military experience, by comparing different forms and methods of training and without the necessary analytical justification. These methods do not provide an opportunity to substantiate the required number of training hours to achieve the required level of training of specialists (units) of the troops (units); use different methods (ways, methods) of researching the process of distribution of education level over time; do not provide for a comprehensive approach to the organization and evaluation of the effectiveness of combat training of a unit taking into account resource limitations. The above confirms the relevance of this study, which is due to the need for scientific substantiation of the amount of training time, which would ensure both the required level of training of specialists of the relevant categories (profile), and the required level of training and combat capability of units of military branches and formations (units) as a whole.

Conclusion

The methodical aspects described in the article make it possible to formulate the law of changes in the level of training (effectiveness of training) $E(x_i)$ of specialists of the i-th category (profile) depending on the number of training hours x_i during which they acquire the necessary knowledge, skills and abilities, and the values of the parameters $\kappa \approx 1{,}33$, $\lambda_i = 0{,}00042$, which most appropriately

reflect the dynamics of the educational process of specialists of any category (profile): $E(x_i)=1-e^{-\lambda_i \cdot x_i^{\kappa}}=1-e^{-0{,}00042 \cdot x_i^{1{,}33}}$ (17), where λ_i is the $E(x_i)$ parameter, which in this case, like the parameter κ, is assumed to be the same for any i-th specialty $(i=\overline{1,\ 4})$.

The given law makes it possible to unambiguously determine the amount of training time necessary to achieve the required level of training of specialists of the military branches of the troops (units).

Recommendations

The number of training hours obtained as a result of the calculations makes it possible to achieve the required level of training of servicemen for the MS (positions) for which the class qualification of a specialist is assigned (are the most difficult), for example, for commanders of combat vehicles (cannons), gunners-operators (cannon gunners), mechanics -drivers (drivers), senior gunners (gunners) of guns, operators (gunners) of anti-aircraft installations, etc.

For the training of military personnel for the MS, who do not require the assignment of specialist class qualifications, for example, riflemen, machine gunners, grenade launchers, the number of training hours may be reduced depending on the level of their acquisition of practical skills and abilities. At the same time, practice shows that the minimum period of training of specialists for MS (positions) that determine the combat capability of units (parts) should be at least three months (468–624 study hours). It should also be taken into account that during a special period, the reduction of the general terms of training (for example, from three to one month) and at the same time an increase in the intensity of the educational process (the number of educational hours per day from 8 to 10) can negatively affect the final result of training.

The methodological aspects presented in the article are aimed at maintaining (developing) the typical FDR-3 capability group (Training of military authorities and troops (forces)) of the FDR functional capability group (Planning the development and ensuring the readiness of troops (forces)). The practical use of the presented methodical aspects will contribute to the improvement of the quality of planning and construction of the process of training troops (forces), and therefore to the growth of their combat capability and ability to effectively oppose the enemy on the battlefield.

Prospects for further research. Given the fact that the methodical aspects considered above do not provide for any restrictions, except for the duration of the training process, in practice there may be a need to distribute training hours between the units of the troops of the unit (unit), taking into account the financial resources allocated for combat training. In this regard, the perspective of further research may be to formulate and solve an optimization problem that, given the given levels of training $E(x_i)$ of specialists (units) of the troops of the unit (unit) and taking into account the importance (contribution) a_i of one or another unit of the unit to the combat capability of the unit (units), as well as the financial resources C allocated for combat training (for the training period), made it possible to determine the resource of training time $x_i(i=\overline{1,4})$, necessary to achieve the given level of training $E(x_i)$ of the main divisions of the military branches and the maximum level of training $\max E(x)$ of the unit (unit) as a whole (Godz, S. V., Taran, O. V., 2019), (Godz, S. V., 2020).

The level of training of the military reserve of human resources is of great importance, in particular conscripts (reservists), who in peacetime are on military registration in territorial recruitment centres, and in a special period are subject to mobilization, and, as specialists under certain MS, arrive for assembly of troops (units) of the Defense Forces. At the same time, it is important to consider the fact that conscripts lose some part of the information (acquired knowledge, abilities, skills) that they have acquired before for a certain period. Under the same conditions, the rate of loss of this information, and therefore the current level of education of conscripts, can be

different. In one case, significant average annual losses of information from memory are observed, in the second case, these losses are insignificant, which is related to the peculiarities of each person's memory and its main properties - memorization and forgetting (memory is a psychological process that characterizes the ability of military personnel (conscripts) to store and reproduce in the mind the information previously acquired during military training). One of the main ways to restore partially lost information in the memory of servicemen (military conscripts) is to periodically conduct military training events with them, for example, training meetings or classes during mobilization events. In this regard, the perspective of further research may also be to substantiate the periodicity and duration of training events with this category of personnel (Godz, S. V., 2020).

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