The Social Sciences 10 (8): 2181-2187, 2015
ISSN: 1818-5800

Operational Injuries Analysis Technique

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Abstract: The probability theory and mathematical statistics making a basis of mathematical apparatus of a reliability theory and also the main properties and indexes of reliability are of great importance and are widely used in methodology of an assessment and the risk analysis. Safety is a desirable condition of the researcher or desirable property of object from which danger proceeds. The risk serves as a measure of this state (or properties) defining danger in the quantitative or other expression. The basic concepts of industrial traumatism are given in the study. Methods of the traumatism analysis their purpose, performance order and advantages are considered. Probability approach to the accident analysis is offered and described. Note that an important factor in probability assessment is stating the distribution laws of traumatism depending on the influencing factors it is possible to apply the normal distribution law (Gaussian distribution) or the Law of Poisson to the practical conclusions. The algorithm of production reliability assessment is constructed. Prime measures of safety in conditions of production are defined.

Key words: Risk, danger, analysis, traumatism, identification, coefficient, severity, frequency

INTRODUCTION

Labor protection is understood as the system of workers' safety of life and health in the course of research including legal, social and economic, organizational and technical, sanitary and epidemiologic, treatment and prophylactic, rehabilitation and other actions and tools (Komleva *et al*., 2015).

The production trauma during performing labor (office) duties that may result in a production trauma, sudden deterioration of health or poisoning of the research leading to temporary or permanent disability, an occupational disease and death is considered in view of harmful and dangerous production factor influence on a worker.

The trauma is defined as violation of wholeness of tissue and body organs under the influence of any external factor (Komleva *et al*., 2015, 2014; Kharkov *et al*., 2012). Reference symptom of a trauma is fast deterioration of tissue and human organs. It occurs during traumatizing or directly following which quite often allows recording the exact time of taking trauma.

Disease is defined as violation of vital signs of an organism. In this respect, the disease is a more common concept which includes the "trauma" concept. From the practical point of view, it is more convenient to consider injuries and diseases separately. This is the approach we adopted.

TRAUMATISM ANALYSIS METHODS

All existing methods of the analysis can be divided into three basic groups: technical, statistical and probability methods. Modern methods of the traumatism analysis, except mathematical statistics and probability theory, use reliability theory analyzing the circumstance that accidents often happen as a result of failures or accidents in mechanical systems. Therefore, the reliability theory studying laws of mechanical malfunctions resulting in accidents is the most perspective in traumatism research.

According to literary data the purpose of the traumatism analysis is to establish the reasons and interrelation of factors which result in accident and to develop recommendations on preventing similar accidents in the future.

Technical analysis methods use laws bound to circumstance of the investigated accident. The commercial analysis has to establish a qualitative picture of events succession in case of accidents. The quantitative assessment of defining factors allows making specific technical recommendations on comfortable working conditions.

The commercial analysis of accidents starts with studying the circumstances preceding it. First of all it studies the production technology and organization of works. Thus, data on factors have to be especially

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carefully brought together, relevant to an accident. The precise reconstruction of a situation prior to the accident is of high, sometimes crucial importance.

Monographic analysis is a kind traumatism commercial analysis. Thus, any object of production can be an object of research. This object is investigated comprehensively from the point of view of possible dangers at its application in the course of research, purpose, tools and ways of elimination of these dangers. Subjects to monographic research are dangerous and harmful factors (objects) peculiar to inventory, site, workshop or technological process.

It is expedient to use this research technique of traumatism at a design stage that allows eliminating easily noticed defects.

The statistical method of the analysis is made on the basis of accident investigation act and the task consists in studying the set of accidents. This method allows receiving some average characteristic of researching conditions thus, the indicators of absolute number of accidents and relative indicators considering number of workers, coefficients of frequency and severity of traumatism are defined. Accuracy of the analysis method depends on basic data reliability.

There are following types of the traumatism statistical analysis: tabular, topographical, correlation and traumatism coefficients type (Komleva *et al*., 2014; Kharkov *et al*., 2012).

The tabular method of the traumatism analysis is the simplest kind of the statistical analysis which is based on grouping of accidents by various indicators in the form of a table. The method allows establishing the most dangerous reasons, factors, traumatism places as well as changing of their specific frequency.

The most widespread method of the analysis of the statistical method of establishing coefficients of frequency and severity of traumatism. The coefficient of traumatism frequency K_B for a certain period of time is determined by number of victims carried to one thousand working on average structure:

$$K_B = \left(\frac{\Pi}{C}\right)1000$$

Where:

Π = Number injured people for this period of time
C = Average payroll of workers for the same period

It should be noted that the coefficient of frequency does not consider severity of accidents at the same time the coefficient of severity of K_T of traumatism characterizes average severity of accidents for a certain period of time on number of disabled days of victims and is calculated by equation:

$$K_T = \left(\frac{H}{C}\right)1000$$

where, H total number of disability days for all victims for this period of time. Besides, the danger coefficient K_o characterizes degree of danger for this production over some danger for subject and is determined by equation:

$$K_o = \left(\frac{\Pi_{HC}}{\Pi}\right)\left(\frac{T_{cp}}{T}\right)$$

Where:

Π_{HC} = Number of accidents at the studied technological process in people
Π = Total number of accidents on object
$T_{тр}$ = Labor input of the studied process (shifts/th.)
T = General labor input of works on object (shifts/th.)

Aside from coefficients K_h, $K_т$ and K_o statistical analysis uses the index of danger, coefficient mechanisms' condition, etc. Index of danger Π_o is described by equation:

$$\Pi_{op} = \frac{\Pi}{T}$$

Where:

Π = Number of injured for the period of time, people
T = Labor input of works (shifts/th.)

Saturation coefficient $K_н$ is determined by mechanisms of a floor space, described by equation:

$$K_M = \frac{S_M}{S}$$

Where:

S_M = The occupied mechanism space (m^2)
S = Total floor space (m)

Equestions show that increase in coefficients K_h, $K_т$, K_{on} and K_o means that the object or process becomes more dangerous and decrease of these coefficients that the object or process becomes less dangerous. It should be noted that steady growth of coefficients is a natural increase in danger of object (process) and is not a casual phenomenon.

The comparative traumatism analysis is made by comparison of the coefficients calculated on above to the given equations. Thus, only comparable coefficients that is the received values for the same period for similar objects are compared.

In traumatism statistical analysis, except the above methods, topographical and correlative analysis methods

which allow submitting traumatism characteristics visually are applied. It is known that the higher the correlation coefficient, especially if values are interdependent, the more definite their correlation is (unambiguous).

It should be noted that the dependence established by correlation analysis including pair correlation is fair only for those conditions for which it has been derived. At pair correlation analysis it is correlated only between index of traumatism and one of defining factors that is algorithm of regression.

THE RISK PREDICTION ANALYSIS METHODS FOR INDUSTRIAL FACILITIES

In practice the analysis of dangers is begun with the rough research allowing to identify generally sources of dangers. Then in need of research can be deepened and a detailed qualitative analysis can be carried out. The choice of this or that qualitative method of the analysis depends on the pursued purpose, mission of object and its complexity. Computational methods of probabilities and a statistical analysis are constituents of the quantitative analysis of dangers. When it is possible to assess damages it is possible to carry out a numerical analysis of risk. In the analysis of dangers always take into consideration the used datas, working parameters of system, existence and a condition of control and measuring tools. Research is finished with offers on minimization or prevention of dangers. The main analysis stages of dangers are shown in Fig. 1 (Kharkov *et al*., 2012). Now use some concepts of the risk analysis in various fields (Fig. 2).

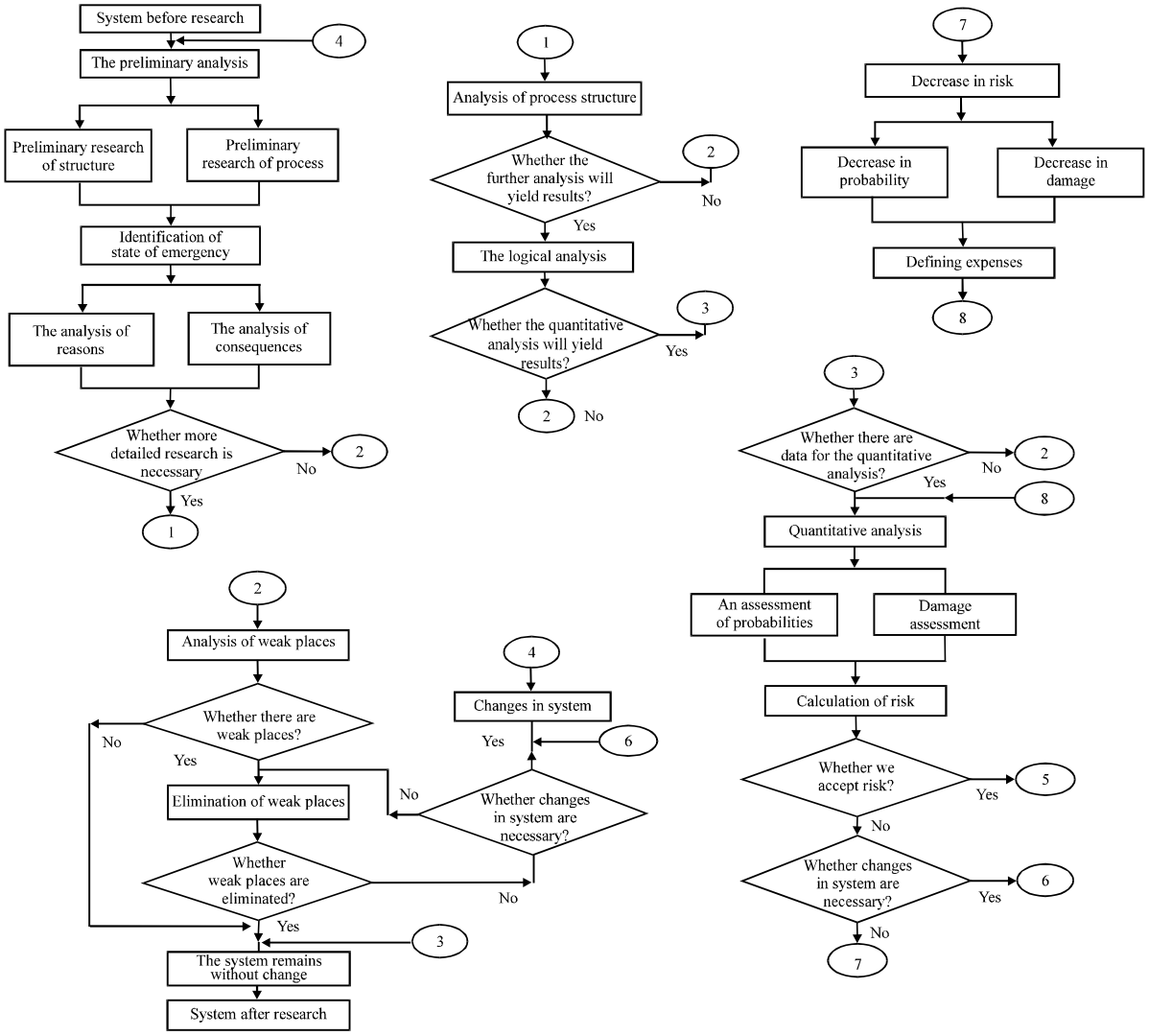

Fig. 1: Procedure of danger analysis

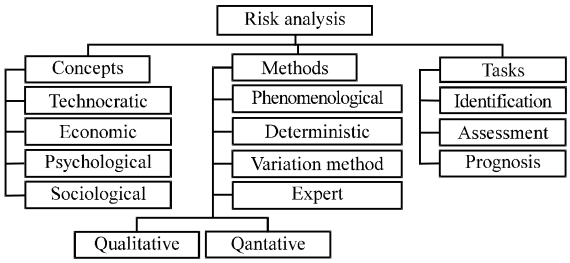

Fig. 2: Methodical means of the risk analysis

PROBABILITY APPROACH TO THE ACCIDENT ANALYSIS

The probability method defines that traumatism depends on many random factors that is we may say that formation of accidents is a probability process.

The probability method of the traumatism analysis is based on some starting statistical data. The more data is available, the more reliable the conclusions received by this method are.

This method applies a number of probabilistic traumatism characteristics from which intensity and severity of traumatism and probability of accident happening are derived.

The probability of accident is established on the basis of the analysis of starting statistical data on accident. It should be noted that most important at a probability assessment is to establish distribution laws of traumatism from the influencing factors.

According to these many researchers (Kharkov *et al*., 2012), it is possible to apply the normal distribution law (Gaussian distribution) or the Law of Poisson to practical conclusions. Equation of the normal distribution law is derived on the basis of the following assumptions:

- The normal distribution of a sign (traumatism) is observed when function of significant feature blocks others causing them to form other significances
- The final error of any measurement represents result of a large number of very small mistakes distributed in a random way
- Positive and negative deviations concerning the true value are equiprobable

On the basis of these assumptions the probability of traumatism can be defined by a equation:

$$P = \int_{-x}^{+x} \frac{h}{\sqrt{\Pi}} e^{-h^2x^2} dx$$

Where:

h = Some constant characterizing this normal distribution called by the module or an accuracy index

x = Frequency of deviation occurrence of rather precise value of traumatism that is the size of traumatism changes from 0 to 1

Under the law of Poisson is calculated the probability of that during time of Δt there will be m of accidents:

$$P_m = \frac{a^m}{m!} e^{-a}$$

where, a is the parameter of the law of Poisson depending on intensity of traumatism:

$$a = \lambda t$$

where, λ is intensity of defining criterion during this period of time:

$$\lambda = \int_{t}^{t+\Delta t} \lambda dt$$

where, t is time. Intensity of traumatism for the particular period of time is defined:

$$\lambda_{cp} = \frac{n}{\Delta t}$$

where, n is number of the analyzed events during time Δt. If traumatism is a stable process then λ = const. Generally, intensity of traumatism is a function of time. Needless to say that the specific case of traumatism has nonstationary character. Therefore:

$$\lambda = \frac{dn}{dt}$$

where, dn is expectation of number of accidents in time dt. Thus, severity of traumatism can be defined as mean time of disability of one or several victims. It is easily possible to define if it is known that in some conditions there will be at least one or two accidents; probability that accident will happen at traumatism process is determined by a equation:

$$P = 1 - e^{-a}$$

Then at known value it is possible to claim P that the probability of work without injuries is equal:

$$P_{bm} = 1-P$$

where, 1 is cooperative probability of work without trauma or emergence of a trauma for a particular time term. Except the above methods of the traumatism analysis there are following methods: economic, ecological and ergonomic.

The economic method applies assessment of the data damage from traumatism, effectiveness of costs of its prophylaxis (Kharkov *et al*., 2012). This method does not always allow to establish the reasons of traumatism and gives an assessment of the data damage and as a result is padding.

It should be noted that the probability method of the traumatism analysis is very detailed and therefore it gives more chance for obtaining recommendations about decrease in traumatism.

The ecological damage considers infliction of harm to the population and a surrounding nature due to pollution of principal components of environment (air, water, soil, plant and animal life) by means of economic sanctions and is based on complex studying of person-to-environment system where the main element is the person. Here physiological, psychophysiological and personal (psychophysical) factors of the person are considered in the course of work.

Efficient and safe operation depends also on biological rhythms of functioning of person's organism and the helio-geophysical phenomena (influence of the Moon, activity of the Sun, magnetic and gravitational fields of Earth). These phenomena influence mentality of the person which may influence his behavior.

Besides, the method of combinational classifications in which the major factors influencing traumatism level share on prime and sometimes on the partial parts is applied to research of the reasons of traumatism.

For the purpose of the accounting of formation nature for the situations leading to accidents which are based on dynamics and inter-conditionality of events dynamic models their sequence and coordination to achieve minimum danger of injuries are offered (Kharkov *et al*., 2011).

CREATING THE ALGORITHM FOR PRODUCTION RELIABILITY ASSESSMENT

The following criteria of indexes are the basis for technique: frequency of accidents which is defined by frequency coefficient K_h, severity of accidents which is coordinated by algorithm of the guarantee prognosis. This criterion is estimated by Bayes's equation and expresses the probable density of joint distribution of traumatism and losses. In compliance with the law the conditional probability criteria are characterized by the following conditions which express rate and severity of traumatizing.

The conditional indicators of operational injuries are considered by frequency coefficient $K_{Ч}$ and loss coefficient $K_{П}$. Index of traumatismfrequency is a median number of the accidents taking place at the enterprise:

$$K_h = \frac{N}{C}$$

The index of traumatism severity is the median number of days of disability at the enterprise:

$$K_T = \frac{D}{N_{mp}}$$

The coefficient of loss is a work of coefficient of frequency on severity coefficient:

$$K_{П} = K_h K_T$$

Individual share of various injuries is defined by a equation:

$$P_n^i = \sum \frac{T_i}{T}$$

Where:

T_i = Number of accidents for the group

T = Total of accidents of all groups

The conditional probability of individual share $P(B_i)$:

$$P(B_i) = \frac{N_{T_p}}{N_o}$$

Where:

N_{Tp} = Number of victims afflicted by the injuring factors

N_i = Total number of victims afflicted bythe injuring factors

The probability of an event A is defined by a equation:

$$P(A) = \sum P(B_i) P_{Bi}(A)$$

Algorithm of the guaranteed severity prognosis $P_A(B_i)$ is defined according to Bayes's equation, expresses a traumatism elementary probability law its severity and it is characterized by regularity:

$$P_A(B_i) = \frac{P(B_i) P_{Bi}(A)}{P(A)} = \frac{K_h N_{Tp}}{P(A)}$$

Thus, probability of workers disability $P_{Bi}(A)$ equals:

$$P_{Bi}(A) = K_{ni}$$

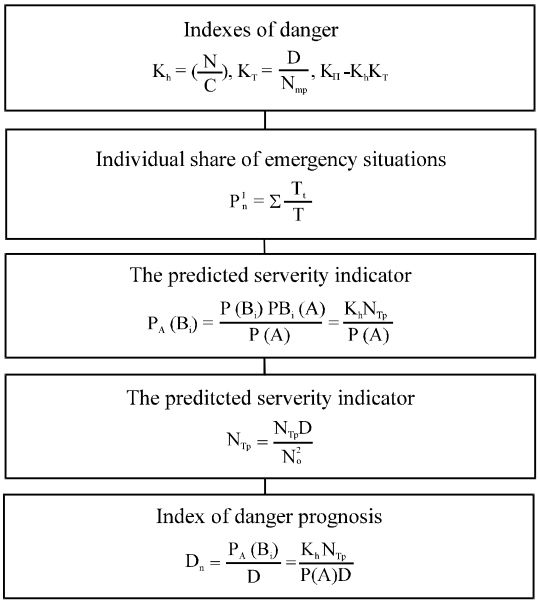

Fig. 3: Algorithm of production reliability assessment

where, K_{ni} is disability of the worker depending on a type of traumatism. Risk condition $N_{тр}$:

$$N_{Tp} = \frac{N_{Tp} D}{N_o^2}$$

Where:

D = Cooperative number of days of disability on all accidents

N_O = Total number of victims afflicted bythe injuring factors

$N_{тр}$ = Number of victims afflicted by the injuring factors

Index of the prognosis of a traumatizing by sign $П_П$:

$$П_П = \frac{P_A(B_i)}{D} = \frac{K_h N_{Tp}}{P(A)D}$$

The given algorithm allows predicting dangers on the basis of conditions of a perspective of the offered process (Fig. 3).

SUMMARY

It is established that the coefficient of frequency does not consider severity of accidents at the same time the K_t coefficient of traumatism severity characterizes average severity of accidents for the particular period of time on number of disabled days for victims. It should be noted that steady growth of coefficients is a natural increase in danger of object (process) and it not the casual phenomenon.

In most cases prime measures of safety as a rule are measures of accident prevention. The choice of safety measures planned for introduction has the following priorities. The measures for decrease of contingency situation including:

- Measures for decrease of probability of incident
- Measures for decrease of probability of incident development into a contingency situation

Measures for decrease of consequences severity for possible accident which in turn have the following priorities:

- The measures provided at projection of potentially dangerous object
- The measures which are falling into systems of the anti-emergency protection and monitoring
- The measures concerning readiness of the operating organization for localization and elimination of accidentcon sequences

CONCLUSION

Dangers and threats, objectively and inevitably present intechnosphere their transformation in accidents, the payment for which consequences became excessive, served as a starting point of the safety analysis by methods of assessment and risk analysis in combination with levels of the admissible risk caused by economic and social factors.

Change in nature and level of threats for safety of society was a consequence of its development within a consumer society. The reached quality standards of life and requirements of society and safety in response to change of level of threats first of all demand perfecting the social organization of society and its social groups. Thus are formed:

- Priorities and proportions of a state policy the economic sphere, providing balance of the vital interests, societies and the states including standards of safety
- Ideology of safety by means of increasing the rile of education and safety culture for person and society
- Rational distribution of the resources of society allocated for ensuring quality of life on satisfaction of requirements and development of society and its safety

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