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# Analysis of concepts about the negative impact of the human factor on the management systems for complex technical objects

**Abstract**

The article examines the way of organizing the means by which it is possible to detect the occurrence of the human factor that has a negative impact on complex technical objects. The system is an organized set of tools for diagnosing the human factor, implemented in the control system and operating in real time. The article develops an approach to the implementation of the human factor diagnosis method, which consists in identifying a dangerous emotional state of a selected person and identifying additional information that causes the activation of the appropriate human factor.

In order to fully present the research problem of the work, an analysis of psychophysiological features of the human emotional state was carried out. Tasks, the solution of which is necessary for the model combined with the human factor, were considered. The analyzed model describes the process of functioning of the human factor and proven methods of organizing the process of diagnosing the human factor in technical facilities.

**Key words**: emotion, service personnel, sensitivity information, model of emotional conditions, simulator, polygraph.

# Analiza koncepcji dotyczących negatywnego wpływu czynnika ludzkiego na systemy zarządzania złożonymi obiektami technicznymi

**Streszczenie**

W artykule zbadano sposób organizacji środków, za pomocą których można wykryć wystąpienie czynnika ludzkiego, który ma negatywny wpływ na złożony obiekty techniczny. System jest zorganizowanym zestawem narzędzi do diagnozowania czynnika ludzkiego, zaimplementowanym w systemie sterowania oraz działającym w czasie rzeczywistym. W artykule opracowano podejście do realizacji metody diagnozy czynnika ludzkiego, polegającego na zidentyfikowaniu niebezpiecznego stanu emocjonalnego wybranej osoby i zidentyfikowaniu dodatkowych informacji, które powodują aktywację odpowiedniego czynnika ludzkiego.

Dla pełnego przedstawienia problemu badawczego pracy przeprowadzono analizę psychofizjologicznych cech stanu emocjonalnego człowieka. Rozpatrzono zadania, których rozwiązanie jest niezbędne dla modelu połączonego z czynnikiem ludzkim. Analizowany model opisuje proces funkcjonowania czynnika ludzkiego oraz sprawdzone metody organizacji procesu diagnozowania czynnika ludzkiego w obiektach technicznych.

**Kluczowi słowa**: emocji, personał serwisy, wrażliwa informacja, model emocyjnego stanu, trenażer, poligraf.

## 1. Introduction

The human factor ($HF$) has a negative impact on the functioning of complex technical objects ($CTO$), which occurs with the participation of service personnel ($SP$) in the management of operational processes ($Pr_i(CTO)$), which leads to disturbances in the processes $Pr_i(CTO)$ and can also lead to accidents and catastrophic situations in the $CTO$.

$HF$ manifests itself as the results of people from $SP$ acting on the management process, carried out under the influence of emotion without the use of processes of analysis of possible causes, the need to take appropriate action and analyse the possible consequences of their implementation. In most cases, the effects of such $HF$ actions on $Pr_i(CTO)$, or $CTO$, in general, are negative. In the case where $HF$ acts on $Pr_i(CTO)$, we will call $HF$ active, which can be denoted by the symbols $AHF$.

The occurrence of $HF$ is first of all caused by certain emotional conditions, caused by psychophysiological parameters ($EPC$), of persons $sp_i \in SP$, the values of which change under the influence of the factors arising in technical, natural, or information environments. Relevant factors will be called active, and separate informational factors will be called active information ($AcI_i$), if the latter leads to a change in emotional condition.

The human factor can also have a positive impact on the environment. An example is the creation of a successful work of art, a successful solution, and others. This confirms that the determining factor in the occurrence of $HF$ is the psychophysiological condition of a human and the emergence of certain external factors, which in combination with $EPC$ determine the possibility of human impact on the environment (Cacioppo et al., 2005).

## 2. Analysis of the psychophysiological features of emotional condition

Human $EPC$ are selected for $HF$ analysis because $EPC$ are an integral manifestation of a certain safe or dangerous, or saturated emotional psychophysiological condition ($NEC$) of a person.

*Definition 1.* Saturated $NEC_i$ is an emotional condition which after some time can lead to a transition to another emotional condition $EPC_j$, or in combination with other factors can lead to $HF$.

One of the most well-known is the thesis that each person is always in one of the possible emotional conditions $EPC_i$, which is characterised by certain parameters (Reykowski, 1992).

The influence of $sp_i$ on a separate fragment of the technological surrounding environment $Ste_i$ can be carried out as a result of the action of a single $sp_i$, which is in saturated $NEC_i$ and some objective factors that cause such influence, which is activated by an external factor of the type $AcI_i$. Among the external factors of the type $AcI_i$ we will consider only sensitive information factors, or ($SeI$), which differ from $AcI_i$ in that their effect on the human condition has a negative impact $EPC_i$. Each environment, for instance, human, natural, technical and others, is characterised by the means implemented in it, which provide for $sp_i$ the possibility of influencing it one way or another (Korostil, Korostil, 2015). An example of such means can be the control bodies ($zu_i$) a fragment of the technological process $Ste_i \in Pr_i(CTO)$, which the corresponding person is focused to work with. The effectiveness of the impact of $sp_i$ on the technical environment can be determined by the following factors:

- the number of authorised means of $sp_i$ interacting with $Ste_i$ provided for $sp_i$ within the service technology $Pr_i(CTO)$ and other means that are not directly intended for $sp_i$, but may be available for $sp_i$;
- the possible degree of influence exerted by each individual means of interaction of $sp_i$ with $Pr_i(CTO)$ on the corresponding process;
- the ability of $sp_i$ to use inaccessible, in normal modes, means and methods of influencing $Pr_i(CTO)$.

*Definition 2.* The degree of saturation of the emotional condition $\mu(EC_i)$ is determined by the nature of psychophysiological parameters $Pe_i(x_i)$, which determine the corresponding condition of $EC_i$, and the values of their values $x_i$.

This can be written as:

$$\mu(EC_i) = Fe[Pe_{i1}(x_1), \ldots, Pe_{im}(x_m)], (1)$$

where $Fe$ is a function that describes the method of determining the degree of saturation, $Pe_{ij}(x_j)$ is a psychophysiological parameter, the value of which is determined by $x_j$.

The maximum saturation of the emotional condition is determined by the formula:

$$\max[\ \mu(NEC_i)] = \sum_{j=1}^{n} Pe_{ij}(\max x_j).$$

The terms "emotion" and "emotional condition" are generally accepted in psychology and allow the psychological condition of an individual to be identified, for example, among people (Ekman, 2012). Emotions of different types can be defined and distinguished through a number of features. The most common feature is a description of how a person reflects it, for example, changes in facial expression. To fully describe the emotion, the values of various psychophysiological parameters that are associated with the person are used. Regarding the psychophysiological parameters of the human emotional condition, the following well-known theses should be noted (Dąbrowski, 2012):

*Thesis 1.* Common to most people are borderline emotions, which have a high degree of saturation.

*Thesis 2.* Within the framework of emotional characteristics, people may differ in emotional conditions, which are not borderline, but, with increasing saturation, the corresponding differences in emotions disappear and approach the emotion that is characteristic of most people and may be common to them.

*Thesis 3.* For all persons, the connections between different emotions, including emotions with low saturation, within emotional models, represent, with a certain approximation, the same structure, which is especially characteristic of persons operating in an environment such as $CTO$.

The third thesis is about the fact that the processes of emotional change for most people in environments such as $CTO$ are quite close. The following information is used to build models of emotional conditions:

- descriptions $EPC_i$ are characteristic of individual $sp_i$, possible transitions from one $EPC_{ik}$ to another $EPC_{ij}$, the regularities of which, in accordance with thesis 3, are described by schemes common to most individuals;
- data of psychophysiological parameters, the values of which are associated with the identified $EPC_i$, can be measured by methods determined in the process of conducting relevant studies $sp_i$;
- data on information messages of different types, for each person $sp_i$ and their groups.

There may be a situation when a vulnerable factor in the form of sensitive information, which we will denote $SeE_i$, arises in the external environment, and acts directly on the $CTO$. In this case, $sp_i$ may not have enough information about such a factor, and this may accelerate the transition $EPC_i \rightarrow NEC_i$. This acceleration may lie in reducing the time interval during which $sp_i$ enters the $NEC$ condition by the corresponding factor (LeDoux, 2000).

The relationships between psychophysiological parameters and patterns of transitions from one condition $EPC_i$ to another $EPC_j$ in the human environment can be to some extent blurred. The occurrence of $EPC_{ij}$ in $sp_i$, the forms of their manifestation and patterns of transitions from one condition $EPC_{ij}$ to another condition $EPC_{ik}$, in the technological environment $CTO$, are largely deterministic, due to the high degree of determinism $Pr_i(CTO)$. Uncertainties that may occur in $Pr_i(CTO)$ environments are related to random events that are not foreseen in the $Pr_i(CTO)$ processes. Such accidental events mainly represent the occurrence of non-design faults in $Pr_i(CTO)$, or unforeseen actions of external negative factors on $CTO$ and so on (Korbicz et al., 2000).

## 3. Problems that are solved while building models related to the human factor

To build models related to the human factor, it is necessary to investigate and solve the following problems:

- explore approaches to creating methods for determining $NEC_i$, for different types of $sp_i \in SP$ based on the use of $CTO$ simulators and polygraphs;
- identify possible $SeI_i$ based on the analysis of critical situations in the $CTO$ and identify changes in $NEC_i$ that may occur under the action of $SeI_i$;
- on the basis of the analysis of processes of functioning of the chosen $CTO$ and characteristic for them $SeI_i$ to construct the generalised possible methods of counteraction to emergence of $HF$.

To solve these problems, it is necessary to use a tool that provides modelling of different classes of $CTO$ and different modes of their operation together with control systems and simulation systems of different components of processes $Pr_i(CTO)$ (Kościelny, 2001). Examples of such tools are hardware and software models of the corresponding $CTO$, which are widely known as simulators ($TR$). Simulators are largely physical models, which complicates the possibility of their widespread use. Within this model, there is a possibility of introducing $SP$ members in selected conditions $EPC_i$, which can be $NEC_i$. In addition, within $TR$ there is a possibility to implement processes of recognition and modelling of $SeI$ for different $sp_i$ in forms which are typical for the corresponding type of $CTO$ (Zurin, Panin, 2003).

The next type of means for the solution of the set tasks allows registration and preliminary processing of the parameters characterising psychophysiological parameters of the persons who are in the corresponding $EPC_i$ and are members of $SP$ to be carried out. Examples of such tools are polygraph systems, the main component of which are computers. Due to this, it becomes possible to widely use software tools for the analysis of human biophysical parameters. Based on the use of data from such analysis, using the appropriate software, is recognised $EPC_i$ members of the service station.

To solve the problems of $NEC_i$ detection, models of the emotional, psychophysiological condition $M_i(EPC)$ are built, thanks to which it becomes possible to detect the possibility of $NEC_i$ in the corresponding $sp_i$. These models are based on the use of emotional images ($EO_i$) of individual $sp_i$. An emotional image is a sequence of descriptions of psychophysiological parameters that make up this image. The description of the parameter consists of an identifier, the value and a description of its interpretation. Interpretation of the parameter describes the relationships between the parameters, their significance for the current image, the nature of the change in the value of the parameter and others (Golińska, 2006). The expediency of introducing the notion of $EO_i$, in addition to the notion of $EPC_i$, is due to the fact that $EO_i$ is $EPC_i$ on the time interval $\delta_i$, in which $EPC_i$ does not change and is described by a separate set of psychophysiological parameters ($Pe_i$), which characterise $EPC_i$ and during the time interval $\delta_i$. Thus, the process of changing $EPC_i$, which $M_i(EPC)$ should reflect, can be described by the corresponding fragment of the model:

$$m^{EO}(EPC) = [EO_1(\delta_1) \to EO_2(\delta_2) \to \cdots \to EO_n(\delta_n)] \quad (2)$$

Data on $Pe_i$ can be obtained from the corresponding studies of $sp_i$ on $PL$ together with their interpretation, which is used to construct a description of the corresponding $EPC_i(sp_i)$. Changes in emotional conditions $sp_i$ occur under the influence of certain factors, the action of which is manifested within the $CTO$ (Strzelasz, Doliński, 2020). The possibilities of these changes are identified through the use of $TR$ and $PL$ systems, which can be combined into one integrated system.

Factors that cause the transition of $EPC_i$ to the $NEC_i$ condition may occur in the $CTO$. Changes in $EPC_i$ that are not related to the transition to $NEC_i$ can also be described in $M_i(EPC)$ models and formed on the basis of relevant psychological research data. You can use a wide range of parameters that are carriers of information about the psychophysiological condition of a human, but in each case uses a limited number of them. Examples of different types of sources of such parameters are: information about motor-kinetic changes occurring in the human muscular system, information formed on the basis of analysis of the human visual system, information obtained on the basis of analysis of facial expressions and a number of other parameters (Imbir, 2012).

For each individual $EPC_i$, which is determined by $EO_i$, we can include the corresponding groups of psychophysiological parameters $Pe_i$, which, with an acceptable approximation, determine $EPC_i$, and affect the degree of its saturation (1). Such parameters can have different forms of their manifestation: due to one or another behaviour $sp_i$, due to specific features that characterise the current condition of a person and others. Examples of such parameters are: voice and speech parameters ($Pv_i$), visual system parameters ($Ps_i$), handwriting parameters ($Ph_i$) and others (Doliński, 2000).

Models of type $M_i(EPC)$ can use a different number of psychophysiological parameters, which will be called the degree of filling of the model, or $\eta M_i(EPC)$. The expediency of entering this parameter is due to the following reasons:

- different tasks in which it is necessary to use $M_i(EPC)$ may require only certain types of psychophysiological parameters;
- the use of psychophysiological parameters may require the implementation of monitoring the magnitude of changes in the values of parameters that describe the process of functioning of $M_i(EPC)$;
- in many cases, it may not be possible to implement processes for monitoring changes in the values of the total number of possible psychophysiological parameters in $M_i(EPC)$.

The need to use $M_i(EPC)$ in solving problems of protection $Pr_i(CTO)$ from the negative impact of $HF$ on them, is based on the fact that the model $M_i(EPC)$ is closely related not only with the functioning of $Pr_i(CTO)$, but also with the occurrence of negative $EPC_i$ in the corresponding $sp_i$. The $M_i(EPC)$ model contains information about psychophysiological parameters, their values and changes in these values over time $\Delta t_i$. Therefore, there is a need to anticipate changes in these parameters in order to identify the possibility of negative states $EPC_i$ in individual $sp_i$.

Due to the development of information tools for $CTO$-type systems, built on the principles of Internet-specific things, or systems in which they are intended to operate, in the complete absence of human control, the problem of protecting such systems from $HF$ remains relevant (Sutton, 2004). This is due to the fact that in systems of this type, there may be a situation where with the elements of this system, or with the system as a whole, a person activates unauthorised interaction. Such interaction may be motivated by negative or incorrect goals in relation to the system. The peculiarity of this case is that the person concerned may not have access to the means of authorised management of the system and then the following threats arise:

- a threat to the functioning of the relevant system;
- the threat of injury to a person who plans to interact with the relevant system in an unauthorised manner;
- threat to the user of the relevant system, which arises as a result of unauthorised interaction of an outsider with the system.

## 4. Building a model of the functioning of the human factor

The causes of negative human factor ($NHF$) include the following:

- Saturated emotional condition of the person $sp_i$, which is negative $Ng(NEC)$.
- Occurrence of non-design fault ($Ne(Pr_i)$)) in $Pr_i(CTO)$, or occurrence of external factor $Ev(Pr_i)$, which is not predictable and negatively affects $Pr_i(CTO)$.
- The appearance of additional information sensitive to $sp_i$, $SeI(sp_i)$, which is associated with $Pr_i(CTO)$.

The model of the negative impact of human factor $M(NgHF)$ on $Pr_i(CTO)$ should contain descriptions of these factors, their interaction and a description of the implementation of the impact of $HF$ on $Pr_i(CTO)$. A formal description of the structure and interaction of the respective elements with each other can be represented in the form of a block diagram, or a logical formula in the form of:

$\{Ng[NEC(sp_i)]\&[Ne(Pr_i) \vee Ev(Pr_i)]\&SeI(sp_i)\} \rightarrow AHF(Pr_i)$, (3)

The factor of $Ng[NEC(sp_i)]$ is formed in $sp_i$ and is described in the emotional model $M(EPC)$. The conditions for changing $EO_i$ to $EO_{i+1}$ for each person are determined individually by means of $\{TR\&PL\}$. According to thesis 3, the general structure of $M_i(EPC)$ can be represented as a formula, which in contrast to formula (2), has a finite $EO_i$:

$$M_i(EPC) = \{EO_{i1}(\delta_1) \rightarrow EO_{i2}(\delta_2) \rightarrow \cdots \rightarrow EO_{in}^k(\delta_n)\}, (4)$$

where $EO_{in}^k(\delta_n)$ is the final or critical emotional image corresponding to the saturated emotional condition $NEC_i$. Within the framework of $M_i(EPC)$ only such sequences $EO_{ij}(\delta_j)$ are considered, which lead to negative saturated emotional conditions $NEC_i$, which is one of the factors that determine the possibility of $NHF(Pr_i)$.

The occurrence of a non-design fault $Ne(Pr_i)$ is detected by the diagnostic system $SD(Pr_i)$ and transmits information about it to $M(NHF)$ or $SD(Pr_i) \rightarrow Ne(Pr_i)$.

The security system $SB(Pr_i)$ detects an external negative impact on $Pr_i(CTO)$ and, if $SB(Pr_i)$ cannot counteract the corresponding impact on $Pr_i(CTO)$, then $SB(Pr_i)$ transmits information about the negative external influence to $M(NHF)$. It is assumed that any $Ev(Pr_i)$ on $Pr_i(CTO)$ leads, at least, to the occurrence of $Ne(Pr_i)$, and in most cases to the occurrence of emergencies and catastrophic situations in $Pr_i(CTO)$.

The emergence of sensitive information $SeI$ in $M(NHF)$ has a number of features that arise from its possible interpretations and are associated with ideas about the psychophysiological human condition (Levis, Haviland-Jones, 2005). An important feature of the saturated psychophysiological human condition $NEC_i$ is that the way out of this condition is possible in the following ways:

- an emotional condition of the type $Ng(NEC_i)$ leads to a tense physical condition in the human body, which lasts a certain time $\delta_j$ until the stress subsides, if it is not supported by factors such as malfunction or negative external influence on $Pr_i(CTO)$, which in formula (3) are written as $Ne(Pr_i)$ and $Ev(Pr_i)$;
- exit from the emotional condition of the type $Ng(NEC_i)$ by the transfer of the corresponding person of the energy of physical stress in the environment, for example, by realising the physical impact on the environment, which means that such exit from the saturated emotional condition is conscious or controlled by an appropriate person.

If in the time interval $\delta_j$, for some person in the condition $Ng(NEC_i)$, certain information is transmitted, which is focused on increasing the saturation of the negative emotional condition, and increasing the saturation of the emotional condition is no longer possible, because $\mu[Ng(NEC_i)] = max$, then $NHF$ can be activated, or $NHF \rightarrow AHF$. In this case, the exit from the saturated emotional condition of the person is carried out without analysing the situation in $Pr_i(CTO)$ and analysing a possible sufficient way to counteract the relevant dangerous situation, by influencing $Pr_i(CTO)$ through the use of available control means corresponding to $Pr_i(CTO)$. The described situation corresponds to an event that represents the realisation of the human factor in the environment $Pr_i(CTO)$.

The above description of $NHF$ corresponds to a situation where all the factors that cause the occurrence of $AHF$ act within a common time interval of the process of operation of the system. The key factor that determines the occurrence of $NHF$ is the psychophysiological condition of the person who is authorised to make decisions on the management of the technical object, which must correspond to the negative saturation $\mu[Ng(NEC_i)$. Other factors such as $[Ne(Pr_i) \vee Ev(Pr_i)]$ and $SeI(sp_i)$ may appear during the time interval $t_i + \Delta t < \Delta T_i$, where $\Delta T_i$ is the full cycle time interval of functioning of $Pr_i(CTO)$, $t_i$ is the moment of occurrence of $\mu[Ng(NEC_i)$, $\Delta t$ is the time interval during which $\mu[Ng(NEC_i)$ is retained and $Ne(Pr_i)\&SeI(sp_i)$ arise and are transmitted to $sp_i$. In this case, it is assumed that it will be impossible to directly counteract from the part of $sp_i$ against events that may be due to factors $[Ne(Pr_i) \vee Ev(Pr_i)]$, taking into account additional information $SeI(sp_i)$. This type of $NHF$ will be called the human factor with its delayed action on $Pr_i(CTO)$, which will be written as $NHF(\Delta t)$. A negative human factor with its delayed effect on the technological environment, or $NHF(\Delta t)$ has the following features:

- the technological process $Pr_i(CTO)$ cannot be stopped until the end of the interval $k\Delta t$ due to natural or technological features of its operation;
- there is no physical possibility to eliminate or counteract the factors $[Ne(Pr_i) \vee Ev(Pr_i)]$ at the time of their occurrence during $\Delta t$;
- the psychophysiological condition $sp_i$ in the time interval $\Delta t$ must be negative, and in the case of negative $EPC_i$ may not have the maximum degree of saturation.

These features mean that $NHF$ had its negative effect on $Pr_i(CTO)$, which will manifest itself in the form of a negative event only after the time $\Delta t$. Thus, $Ne(Pr_i) \vee Ev(Pr_i)$ and the information in $SeI(sp_i)$ should be probabilistic, which leads to a weaker effect on the degree of saturation $\mu[Ng(NEC_i)$. A characteristic feature of $NHF(\Delta t)$ is that this type of $NHF$ can be implemented in the process of preparation $Pr_i(CTO)$ to start the process of operation of the technological object, but provided that this process involves a person of type $sp_i$, which may relate to $NHF(\Delta t)$.

## 5. Diagnosing the human factor in a technical object

Diagnosis of the human factor lies in identifying and counteracting its negative impact on $Pr_i(CTO)$. NHF detection requires knowledge of the parameters that characterize the NHF implementation process. Since the process of $NHF$ is associated with the psychophysiological condition of a person, it is necessary to be able to determine and assess the relevant psychophysiological condition in order to implement the processes of diagnosis of $NHF$. A person's arbitrary psychophysiological condition is accompanied by changes in the values of various psychophysiological parameters, so it is possible to recognise and measure the values of these parameters. In the vast majority of healthy people, the possible psychophysiological condition and processes that cause them and their possible deviations are stable and determine the psychophysiological status. Such psychophysiological status is a definite, generalised status of a person, which we will denote by $PS_i(sp_i)$. In contrast to the emotional image $EO_i$, which reflects the psychophysiological condition at time $\delta_i$, the status $PS_i(sp_i)$ allows the person to be assigned to a particular psychophysiological class $\mathcal{K}_i(PS_i)$. The characteristic $PS_i(sp_i)$ describes the possibility of an individual to find himself in one or another $Ng[NEC_i(sp_i)]$. Psychophysiological status $PS_i$ is a description of a possible critical emotional condition, described by the image $EO_i^{Kr}$, which may exist over time, the interval of which is greater than the maximum value $\delta_i$ of the person in $i$-th emotional image not less than some value of the time interval $\Delta t_i^{PS}$, which can be written as:

$$\{[\max(\delta_i) \in \forall[EO_i(\delta_i)]\} \leq \{\tau = [\max(\delta_i) + \Delta t_i^{PS}]\}.$$

Different emotional images $EO_i(\delta_i)$ are associated with changes in the values of the parameters $Pe_i(sp_i)$, and the latter load different human biological systems, for example, the muscular system, determined by their tension, the circulatory system, manifested in changes in blood pressure and others (Ekman, Dawidson, 2000). Appropriate systems allow limited loads. Therefore, the model $M_i(EPC)$, when the boundary loads occur, passes into a state in which the next $EO_i(\delta_i)$ passes into $EO_{in}^k(\delta_n)$. This means that $EPC_i^k(\delta_n) \rightarrow PS_i(\tau_i)$, and the latter is the psychophysiological status of the person. It follows that the different $PS_i(\tau_i)$ for an individual are constants and characterise $sp_i$. This consistency is due to the stability of the limit values of the allowable loads on the physiological systems of the individual. Due to this, it becomes possible for an individual, using tools such as $TR\&PL$, to determine the values of the parameters of human biological subsystems $Pe_i(sp_i)$, which can be used to detect $Ng[PS_i(\tau_i)]$. The values of such parameters can be determined at different levels of the degree of saturation $NEC_i$, which can be associated with different values of the factors that cause $EPC$. This makes it possible to establish relationships between excitatory factors that cause changes in the values of $Pe_i$ and the degree of saturation of the $EPC$ of the person, which allows changes in $\mu(NEC_i)$ to be linked with the influence made on $sp_i$ by excitatory factors. Based on the analysis of changes in the values of the parameters $Pe_i(sp_i)$ and the relationships between excitatory factors and the corresponding parameters, it is possible to predict the occurrence of certain negative psychological conditions of individuals.

The next, obligatory, factor that causes the appearance of $NHF$ is the occurrence of a fault $Ne(Pr_i)$ in the system $Pr_i(CTO)$, or a negative impact on $Pr_i(CTO)$ of some external factor $Ev(Pr_i)$, which ultimately leads to a fault in $Pr_i(CTO)$. Since $Ne(Pr_i)$ deals with the diagnostic system $SD(Pr_i)$, and the detection of $Ev(Pr_i)$ is the job of the security system $SB(Pr_i)$, the diagnostic processes $Ne(Pr_i)$ and the operation of the security system will not be considered.

The last mandatory component that causes $NHF$ is sensitive information or sensitive data $SeI_i(sp_i)$. The component $SeI_i$ has no analogues in the theory of diagnostics and, to a greater extent, may relate to general safety problems of the functioning of $Pr_i(CTO)$. At the same time, security issues must go beyond the technological environment itself. For a more constructive approach to the description of $SeI_i$, we introduce the following extension of ideas about additional factors related to $SeI_i$. When it comes to events or factors in relation to which it is planned to implement the solution of problems $Pr_i(CTO)$, the necessary condition is the availability of certain information about the relevant factors. For example, when it comes to diagnosing faults in a technical system, the possibility of detecting faults requires certain information about possible signs of malfunction, even if they are non-design faults. Such information should include information on the parameters and other technical features that are necessary to identify faults and to establish ways to deal with these faults. A similar situation applies to sensitive data $SeI_i$, which can affect the level of emotional condition of the person serving $Pr_i(CTO)$. The difference between $SeI_i$ and fault information $Ne(Pr_i)$ is as follows.

The information about $Ne(Pr_i)$ of the technical object itself contains technical parameters and their limit values that are directly related to the processes $Pr_i(CTO)$, regardless of whether $Ne(Pr_i)$ is caused by internal negative events in $Pr_i(CTO)$ or factors of type $Ev(Pr_i)$.

Due to the fact that $Pr_i(CTO)$ is an artificial object designed and manufactured in accordance with the documentation, the information about possible $Ne(Pr_i)$ can be quite adequate to the corresponding $Pr_i(CTO)$.

Information of the type $SeI_i$ refers to the environment which is external in relation to $Pr_i(CTO)$. It may be components directly related to $Pr_i(CTO)$, an example of such components may be passengers or environments, indirect or direct interaction with which is provided by the corresponding design of $CTO$.

The processes of direct impact of $Pr_i(CTO)$ on the environment must be foreseen at the design stage of the corresponding $Pr_i(CTO)$ and therefore, the processes of interaction of $Pr_i(CTO)$ with the environment are known to the nearest parameters their approximate values. In this case, $SeI_i$ is a description of possible deviations of the processes of interaction $Pr_i(CTO)$ with $Ev(Pr_i)$, which lead to negative changes, the development of which causes the emergence of catastrophic situations in the environment.

The processes of indirect impact of $Pr_i(CTO)$ on the external environment are less known, because the indirect processes and the corresponding factors do not explicitly participate in the implementation of such influence. Information of the type $SeI_i$is formed on the basis of data obtained from the detected non-design faults $Ne(Pr_i)$ that interact with the external environment and from the factors that arise as a result of such interaction.

We can assume that $SeI_i$ is formed as a result of the functioning of the model of interaction of $Pr_i(CTO)$ with the environment $Ev(Pr_i)$, which we will denote by $M(Ev, Pr_i)$. This type of model is used in environmental research, which is designed to study the impact of technological processes on the surrounding environment.

The differences between $SeI_i$ and $Ne(Pr_i)$ illustrate that $Ne(Pr_i)$ characterise the negative events occurring in $Pr_i(CTO)$, and $SeI_i$ characterise the negative events in the larger extent in the external environment due to the processes $Pr_i(CTO)$. To ensure a constructive approach to the formation of information $SeI_i$, we accept the following conditions.

The processes generated by $Ne(Pr_i)$ lead to malfunctions in functioning of $Pr_i(CTO)$ and to the destruction of this process as a whole if $Ne(Pr_i)$ is not eliminated within the framework of fault management. Such destruction will not be considered catastrophic, because the design of $Pr_i(CTO)$ must take into account the possibility of such events, by creating means to protect people belonging to the environment $Pr_i(CTO)$ and protect the environment from the possible negative impact of $Pr_i(CTO)$ on the external environment.

Processes that cause negative events that lead to harmful changes in the environment with which $Pr_i(CTO)$ interacts are described within information such as $SeI_i$. Assume that the degree of negative impact of $Pr_i(CTO)$ on the environment increases with increasing degree of destruction of $Pr_i(CTO)$. In this case, we assume that the destruction of $Pr_i(CTO)$ leads not only to harmful but also to catastrophic changes in $Ev(Pr_i)$.

In order to be able to form $SeI_i$ with the corresponding data, the processes of interaction of $Pr_i(CTO)$ with the environment must be described within the $M_i(NHF)$ model. The environment $Ev(Pr_i)$ can be a passive, active or aggressive environment, which in relation to $Pr_i(CTO)$ shows certain ways of interaction of a different nature. We assume that $Ev(Pr_i)$ is active and under the influence of $Pr_i(CTO)$, or as a result of the interaction of the processes of the medium $Ev(Pr_i)$ with $Pr_i(CTO)$, factors are formed which affect the $CTO$ in general. This means that from the model $M(Ev, Pr_i)$, which is part of the model $M_i(NHF)$ and describes the interaction of $Ev(Pr_i)$ with $Pr_i(CTO)$ it is possible to derive information of the type $SeI_i$, for its use in descriptions of the processes of formation and influence of the human factor on $Pr_i(CTO)$.

Among the possible technical facilities there are a number of facilities that in each case do not pose a significant threat to the environment. In such cases, there is also the possibility of a negative human factor. Objects of this type will be called technical systems of limited influence ($SLI$). In this case, the source of $Ne(Pr_i)$ and $SeI_i$ for the model $M_i(NHF)$ will be $SB(Pr_i)$. The threats detected by the $SB(Pr_i)$ system are divided into two classes according to the criterion, which is a measure of the completeness of the information about the detected threats, which we denote by $\pi(IZ)$. If it is possible to deduce from $IZ\&SB(Pr_i)$ a method of realisation of counteraction to threat, then the threat belongs to a class of the reasons of occurrence of emergency situations. If it is not possible to make a corresponding conclusion due to insufficient informational description of the corresponding threat, then the threat belongs to the class of causes of catastrophic situations. In the second case, information of the type $SeI_i$ is formed, which is transmitted to the model $M_i(NHF)$. Any threat posed to $Pr_i(SLI)$ environments always adversely affects the $Pr_i(SLI)$ process, regardless of the class to which the threat belongs. This effect is recognised by the sensors of the $SD(Pr_i)$ system and the means of $SB(Pr_i)$, based on which information messages of the type $Ne(Pr_i)$ and $SeI_i$ are formed, which are transmitted to the model $M_i(NHF)$. If the threat falls into the first class of threats, then an information message of the type $Ne(Pr_i)$ is formed and $NHF \rightarrow ANHF$ does not occur. The $SD(Pr_i)$ system is focused on detecting faults caused by internal causes. But the negative impact of threats on $Pr_i(SLI)$ also leads to changes in the functioning of the $Pr_i(SLI)$ system, to which the corresponding sensors in $SB(Pr_i)$ respond, which also leads to the formation of $SeI_i$ due to factors of $Ev(Pr_i)$.

## 6. Conclusions

The main approaches to the organisation of $CTO$ diagnostic tools in relation to the action of human factors on them are developed in the work. It is shown that such tools should consist of two systems, one of which is a system for training or education of service personnel, and the second system is a system for human factor diagnostics, which operates in real time operation of the $CTO$.

Within the first complex all information concerning each person comprising the service personnel is defined. First of all, such information concerns the determination of psychophysiological features of individuals, on the basis of these data psychophysiological models are formed for each person. The idea of emotional conditions of the corresponding persons is used as the general psychological characteristic. The system, which is a complex of personnel training that serves the $CTO$, consists of a system of simulators with advanced functionality and a system that uses polygraph technology to determine psychophysiological parameters, the values of which are associated with different psychological conditions of the individual, which are closely related with their emotional conditions.

The system that solves the problem of diagnosing the occurrence of a possible negative psychophysiological condition, detects the corresponding condition in order to further implement the processes of counteracting the negative impact of the human factor on the technological process. Such a system operates in real time during the operation of the $CTO$ and, in accordance with the chosen strategy, monitors the occurrence of negative emotional conditions in each person who is part of the service personnel.

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