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Ergonomiczne metody poznawcze w ocenie zagrożenia psychospołecznego w systemach pracy

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METHODS OF COGNITIVE ERGONOMICS IN ASSESSMENT OF PSYCHOSOCIAL RISKS IN WORK SYSTEMS

ERGONOMICZNE METODY POZNAWCZE W OCENIE ZAGROŻENIA PSYCHOSPOŁECZNEGO W SYSTEMACH PRACY

Abstract

The contribution focuses on the characteristics of human psychic workload, mental performance and reliability in work systems. In the context of defined new psychosocial risks it deals with the possibilities of assessment of human psychic workload and mental performance using the methods of cognitive ergonomics. It draws attention to some possibilities of methodological approach to the evaluation and optimization of human mental workload and reliability, presents the specifics of selected methods for applications in the standard and extreme conditions of work execution.

Streszczenie

Artykuł skupia się na charakterystyce obciążenia psychicznego człowieka, funkcjonowania psychicznego i niezawodności systemów pracy. Główny kontekst, to nowe zagrożenia psychospołeczne i możliwości oceny ryzyka wynikającego z obciążenia psychicznego człowieka i wydajności umysłowej z wykorzystaniem metod poznawczych ergonomii. Autorka podkreśla wybrane metody oceny i optymalizacji obciążenia psychicznego człowieka i niezawodności, przedstawia specyfikę wybranych metod do zastosowań w standardowych i ekstremalnych warunkach wykonywania pracy.

Introduction

The correct assessment and evaluation of human position in a work system assume respecting the balanced view on both significant aspects – technical and human. Only if this assumption is satisfied, long-term effective results can be expected [14]. The achievement of them is conditioned by the consistent utilisation of scientific findings concerning the predispositions and capacities of human individuals in relation to equipment according to its specifications, purpose of evaluation and design of new functional systems. Technical, economic, organizational and human factors as parts of the work system influence human behaviour and well-being [8]. Work systems may differ in complexity and properties, and contain various

combinations of people and equipment in the given space and environment, various interactions among these influences in the framework of work organization.

All activities, including mainly physical ones can be a cause of mental stress. “Mental stress” is in this case a term designating the external action on humans that affects them psychically. The mental stress induces the states of increased and decreased mental strain in humans. An immediate consequence of mental strain is either relief or mental fatigue or states with symptoms similar to those of fatigue [7]. An indirect consequence of the mental strain may be a training phenomenon. The mentioned consequences of mental strain may differ in form and intensity depending on individual and situational initial conditions. The term “mental” is used wherever human experience and behaviour are talked about and is related to human cognitive, information and emotional processes. The goal-directed optimization of working conditions from the point of view of human mental performance influences decisively the quality and the reliability of the whole work system.

Definition of Human Psychic Workload and Performance

The definition of psychic workload for the purposes of work categorization according to the relevant legal regulation [15] is based in the Czech Republic on general principles of assessment of objective indicators of psychic workload in cases given below, when e.g. work is in disaccord with normal human biorhythms, is subjected to the operation of machinery at a forced pace of work or when the condition of monotony is satisfied. The above-mentioned indicators can be defined as such indicators that are a source of psychic workload in each human regardless human mental predisposition.

Work at a forced pace is understood as such manner of working at which the worker cannot select the pace of work and his/her activity is subjected to the rhythm of machinery or other persons. Very unfavourable is a combination of the forced pace of work and the high frequency of work actions. The forced pace of work can be induced even by the rhythm of the set task. For the activity with a forced pace of work and the rhythm of conducted actions or operations, the characteristic feature is direct dependence on technological conditions. It is a case of strict subordination of the worker to the technological process. The worker cannot leave his/her workplace without being replaced; the time designated for a work operation has to be always met, the determined operation has to be carried out on each piece. Furthermore, it is a case of activities done at technologically-interconnected workplaces and thus temporally dependent on each other, when after completing the operations, a half-finished product has to be moved to a technologically follow-up workplace.

Monotonous work is understood as a work activity characterised by repetitive movements or tasks with a limited possibility of worker's intervening into this activity. For the needs of practice, two forms of monotony are usually defined:
monotony of movements – i.e. repetitive manual activity of the same type that consists of simple movement actions; monotony of tasks – i.e. repetitive work activities with the small number of and the low variability in the types of actions (e.g. operation of simple machines, i.e. loading and unloading of workpieces), situation having the small number of and low variability in stimuli.

Another example is so-called vigilance activities consisting in the observation, identification of stimuli and responses to irregularly occurring changes in certain processes. During various activities, both the forms of monotony are usually interconnected.
For basic screening evaluation, two criteria as given below are observed in practice:
– duration – time of movement operation (cycle);
– number of repetitive operations in one shift.
The high monotony of movements means the monotonous execution of maximally 2 movement work operations alternating every 3 minutes as a maximum. The high monotony of tasks means the monotonous, constantly repetitive execution of one simple task.
The increased monotony of movements means the monotonous execution of the limited number of maximally 5 movement work operations every 5 minutes as a maximum. The increased task monotony means repetitive execution of 2-3 simple tasks of the same kind.

Three-shift work and work only on fixed night shifts are in disaccord with natural human biorhythms. Especially unfavourable is the regularly recurring work with variable duration of workshift and with an irregular distribution of working hours in conditions of continuous operation. Other works are, from the point of view of psychic workload and increased requirements put on mental performance as follows: work under temporal stress (with a high pace and limited possibilities of breaks and rests, which is a cause of outbreak of fatigue and insufficient possibility of recovery of organisms), work associated with high demands in the area of negotiation and mutual co-operation between individuals and activities, work when a worker is subjected to interpersonal conflicts, frustration and negative emotional stresses, and work with a risk of endangering the health of other people that represents activities during which rules of safe behaviour have to be strictly kept and the mental demands of work follow from the possible risk.

Other factors that affect the psychic workload are the influences disturbing concentration at work, organizational and material responsibility, works executed in remote workplaces and works associated with social isolation, works with increased demands on the other sense

organs, works during which all requirements from the point of view of occurrence of health risks are not respected.

The evaluation of psychic workload is not prescribed methodologically – by measurement and measurement methods. The solution for human mental performance itself is not prescribed in any way. Principles for the evaluation of human mental workload are included in relevant international standards. By the term **mental stress** we understand a complex of all evaluable influences of external sources affecting humans mentally. By the term **mental strain** we understand the immediate effect of mental stress. The training phenomenon is defined as a permanent change in individual performance, associated with the process of learning, as a consequence of repetitive control of mental strain. Stress inside the individual (not its long-term effect) depends on individual qualities and current background, including the individual style of its control. However, in the Czech professional literature, a stress-stressor pair has often been used recently. To the term *stress,* the term *mental strain* or *mental stress,* or *mental workload* corresponds. To the term *mental stress,* the term *stressor* corresponds [4].

The ergonomic principles related to mental workload are contained above all in the following standards [1, 2, 3]:

- ČSN EN ISO 10075 (833572) Ergonomic principles related to mental work-load. General terms and definitions.

  This standard also states (in examples) relations among environmental mental stress (task requirements, physical factors, social and organizational factors, social factors – external), individual factors (aspiration level, abilities, skills, knowledge, experience, health, physical constitution, age, food, current conditions, initial level of activation) and current mental strain and its immediate effects.
- ČSN EN ISO 10075–2 (833572) Ergonomic principles related to mental workload. Part 2: Design principles.

  It specifies recommendations for the design of work systems, including the design of work task and equipment, design of workspaces and working conditions. It deals with the correct design of work and utilisation of human capacity.
- ČSN EN ISO 10075–3 (833572) Ergonomic principles related to mental workload – Part 3: Principles and requirements concerning methods for measuring and assessing mental workload.

  It defines the principles and requirements concerning the methods of measurement and evaluation of mental workload, including some demands on applications.

Emerging Psychosocial Risks

In the world of work, significant changes take place that bring new demanding tasks in the area of safety and health protection of workers. These changes result in newly emerging psychosocial risks. These risks, related to the way work is designed, organized and controlled and to the economical and social contexts of the work, lead to an increased level of stress and may have very unfavourable impact on both mental and physical health [6].

New forms of employment contracts and job insecurity

The introduction of low-guarantee contracts of work together with the trend towards "lean production" (production with the maximum utilisation of the work potential) and "outsourcing" (utilisation of external firms to carry out the work) may impact on the health and safety of workers. Workers with precarious contracts usually carry out the most hazardous jobs, work in poorer conditions, and less OSH training is given them. Jobs on unstable labour markets may lead to the feelings of job insecurity and to the high level of stress related to work.

Ageing workforce

One of the consequences of the ageing population and the higher retirement age is the older workforce in Europe. The experts who participated in working out the forecast state that ageing workers are in comparison with younger workers more endangered by risks following from poor working conditions. The fact that any opportunities of lifelong learning are not given to ageing workers increases the mental and emotional demands that are put on them. This may affect their health and increase the probability of work-related accidents. If we want to support healthy and safe work in the course of prolonged working life, it is necessary to provide good working conditions that are adapted to the needs of all workers, including ageing workers.

Work intensification

Many workers have to handle at work the growing amount of information and are exposed to increasing workloads. Some workers, above all those in new activity sectors and/or in highly competitive areas, fell somewhat uncertain themselves. These workers are often afraid that their efficiency and outcomes of their work are assessed more strictly and hence they work longer to accomplish their tasks. Sometimes, they are not compensated adequately for longer

working hours or are not sufficiently appreciated. A higher workload and higher demands put on the smaller number of workers can lead to an increase in the level of work-related stress and can impact on the health and safety of workers.

High emotional demands at work

This problem is not new, but it raises a great concern mainly in fast-growing and highly competitive healthcare and service sectors. As one of the factors that contribute to the high emotional demands put on workers, bullying is designated by the experts. The problem of violence and bullying can affect all occupations and activity sectors. In both victims and witnesses, violence and bullying lead to stress and can impact seriously on mental and physical health.

Missing work-life balance

Problems at work can be transferred to private life. Precarious casual work, high workload and variable or unpredictable working hours, especially if the worker has not any possibility to arrange the work according to his/her needs, may lead to work-life conflicts. The result is missing work-life balance, which affects adversely the mental well-being of workers [3].
All defined areas of new psychosocial risks in changing working conditions also influence the level of human mental workload and affect thus human performance and reliability in real work systems in both normal and extraordinary working conditions. Only a systematic approach taking into account all possible aspects can lead to an increase in human reliability, and thus reliability of the whole work system.

Specifics of Measurement and Mental Workload Evaluation

Key international standards on the definition of ergonomic principles in relation to mental workload in work systems also contain indispensable recommendations from the following points of view:

- **fatigue** – intensity of mental workload, ambiguity of work goals, complexity of requirements, strategic procedures, information adequacy, information ambiguity, signal discernibility, redundancy – redundant information, compatibility, information processing accuracy, parallel and series processing, time sharing, time delay, mental models –

inconsistent, incomplete, missing, absolute and relative assessment, demands on working memory, demands of long-term memory, discrimination and recalling from memory, decision-making support, verifiability, range of movement performance, controlling dynamics, methods of observation, maximum permissible errors, consequences of errors, aspects of working environment, social relations, dependence on the performance of co-workers, changes in requirements for setting, time pressure, workload time distribution, duration of working time, breaks between subsequent working days or shifts, day time, breaks, shift work, rest periods during working time, changes in tasks with various requirements or kinds of mental workload;

- **monotony** – where any changes in the structure of task by technical or organizational methods are not possible, the following items are to be taken into account:
  - mechanization or automation of repetitive functions with reduced requirements,
  - rotation of work activities,
  - expansion of the sphere of work activities,
  - work activity enrichment.

  In relation to the monotony, aspects leading to its increase should be considered (absence of co-workers, reduced possibility of social interaction, lack of breaks, lack of possibility of physical activity, lack of possibility of changes in setting, fatigue, monotonous acoustic situation, microclimate, day time) and their effects should be prevented from occurring during the execution of work tasks;

- **reduced vigilance** – the following goals have to be considered:
  - To minimize the requirement for continuous attention for the detection of critical signals.
  - To eliminate the requirement for sustained attention for a long time. The acceptable time depends on the frequency of signal discernibility, probability of signal occurrence, probability of critical signal occurrence and probability of irrelevant signal occurrence. It reduces performance in tasks when a signal is low/frequency is high, probability of critical signals is low, signal discernibility is low. In such conditions, the performance can diminish very rapidly, e.g. after 10 to 20 minutes. Such tasks are to be eliminated. If this is not possible, relatively short time periods without breaks are to be allocated to setting by organizational means. For this purpose, rest periods, rotation or changes in work can be used.
  - To ensure appropriate signal discernibility by a suitable design of communication

receiver and/or a suitable design of working conditions (e.g. appropriate lighting, reduced noise level).

- To eliminate the requirements for gradual discernment, when reference data has to be remembered, and instead of it to use the existing discernment based on reference data represented on the suitably designed display.
- To improve a possibility of detection of uncertain signals (temporal, spatial, visual) as much as possible. To use feedbacks for this purpose.
- To provide the operator with certain technical means to evaluate and improve the performance of the operator.
- To minimize or eliminate factors leading to monotony.

- **satiation –** to prevent the mental satiation of operators, it is necessary to satisfy many requirements and to acquire more information concerning the executed activity and to minimize them:
  - by suitable division of functions between the operator and the machine, e.g. by automation of simple repetitive task elements,
  - by suitable division of tasks among more operators, e.g. by combination of various elements of the task for each individual instead of assignment of identical tasks to each operator,
  - by setting the meaningful tasks that are taken as a larger whole instead of simple tasks and the importance of which to the accomplishment of the whole task can be understood by the operator,
  - by setting the tasks that enable personal development, e.g. tasks when one can or has to learn something, tasks that enable various ways of executing according to skills and abilities,
  - by task enrichment, i.e. by combining the elements of tasks on different levels of their accomplishment, e.g. combination of assembly and check and maintenance,
  - by expanding the task, i.e. by combining various elements of the tasks on the same level of accomplishment, e.g. assembly of various parts or the whole unit,
  - by rotation of work tasks, i.e. systematical rotation of various working postures with specific requirements,
  - by time structuring of the work process by means of rest periods,
  - by quantitative structuring of the work process using the determination of performance goals for gradual accomplishment of the tasks with performance feedback,

- by minimization or elimination of the conditions that lead to monotony or reduced attention.

It should be noted that the worker's qualities, e.g. education, skills and training are of special importance to the occurrence of mental satiation. The greater complexity of cognitive functions will lead the operator to the faster perception of structural similarities, and thus to satiation. When designing tasks, special attention should be given to the selection of operators from the point of view of prevention of mental satiation. The ergonomic principles in relation to mental workload are specified also for information passing on and for operator training [1, 2].

Principles of Mental Workload Evaluation

In the course of specification of level of precision at which the tool can be used, the objective of measurement should be set. It should be determined whether the objective of measurement is a human or a situational attribute. If the set objective of measurement is an individual, psychometric attributes for human measurement should be determined and specified. If the set objective of measurement is the situational characteristics, the psychometric attributes should correspond to the conditions of evaluation [5,10,4]. During the specification of level of precision, at which the tool can be used, it is also necessary to distinguish whether the measurement is based on individual evaluation/observation or on average evaluation/observation [4], [5], [6].

All procedures of evaluation will necessarily contain measurement errors that can be reduced by decreasing (averaging) the number of results/observations. The tool by means of which the screening level of requirements for individual results/observations will be achieved, can reach the verificative level of requirements for average results/observations, if the sufficient number of observations are used. To achieve the higher level of precision, the required amount of results/observations has to be specified. The tool ascertaining the mental workload has to prove validity at the determination of those aspects in which validity is required, and the areas of measurement in which validity is required, have to be clearly stated (for instance psychic fatigue or monotony). If validity is required in more than one aspect, its documentation should include the records of all areas of measurement. For mental workload evaluation, various methods can be used, of which some are suitable only for certain areas of measurement.

Above all the following methods can be used:

- physiological measurements: these methods provide information on the physiological state (physiological response) of workers under given working conditions;
- subjective measurements (subjective scaling): these methods provide information about how workers subjectively evaluate various aspects of mental workload in their workplaces, for example by using psychometric scales, and about how they feel in working conditions;
- performance evaluation: these methods offer a possibility of evaluating human psychic and psychometric performances under given working conditions, for instance for the purpose of evaluation of decrease or change in performance due to the mental workload;
- work and task analyses: these methods evaluate parts of tasks, physical and psychosocial working conditions. Conditions given by the environment and organization of work processes as sources of mental workload.

To achieve various levels of reliability, various methods will be required, e.g. a brief questionnaire may be appropriate for screening measurements, whereas for the verification whether the design of work system does not lead to monotony, scales with corresponding reliability will be required for this purpose. To avoid the negative influences of safety-critical and dangerous systems on mental workload, the highest reliability and validity are required. For the given purposes, methods with the highest available psychometric criteria should be used. The precision is not determined by the measurement technique itself, but it is determined by its implementation, psychometric attributes and adequate use of the method or the tool. If the measurement methods not corresponding to the requirements are used, it is necessary to require special professional assessment in the area of mental workload and its measurement for assessing risks associated with the use of unsuitable technical equipment and for achieving the serious evaluation of results. The selection of the corresponding tool will be however always influenced by legal and conventional regulations as well as by questions of costs and benefits.

Methods of Ergonomic Evaluation of Work Systems

The methods of ergonomic evaluations are an investigation tool usable for the evaluation and assessment of characteristics of the user and the system itself. Their application follows from the requirements given by the abilities, limits and requirements of all elements of the system [7, 9]. For the assessment of human capacities and predispositions in the specific conditions of work systems, suitable methods of ergonomic activities, which take into account the human

and the technical aspect of work performance and reliability requirements, are used. The following methods, classified according to the purpose of use, supplement the standardized methods of ergonomic evaluations or at least respect principles determined by them; publications about their applications are available. The stated classification provides a picture of the wide spectrum of the methods [12,13]. The applications of some methods are variable, modifiable, multi-purpose, and results depend on specific conditions.

- ***Data Collection Methods***

  Data collection methods are used for the collection of specific data related to the system and scenarios. They are basic methods for designing and planning new systems and for assessing currently operated systems.

- ***Task Analysis Methods***

  These methods are used for analyses of human position and human role in executing tasks and scenarios in systems. Analytical methods specify tasks and scenarios (e.g. working procedures, task contents) to individual steps, for human-machine, human-human (other persons) interactions.

- ***Cognitive Task Analysis (CTA) Methods***

  CTA methods are used for the description of yet not known sets of arrangement of activities and actions. They are used in the description of mental processes of system operators in the course of completing and making up operations to be performed and their sets.

- ***Process Charting Methods***

  They are used for the graphic representation of tasks and processes by means of standardized symbols. The output of process charting methods and techniques can be a basis for the cognition and understanding of different sequences of tasks that are contained as part in the overall scenario – a detailed overview of work activities. Furthermore, they are used for the clarification of time schedules of operations that may occur and for the clarification of which technological aspects of the system and its relations are required.

- ***Human Errors Identification (HEI) Methods***

  Human error identification methods are designed for the prediction, identification of possible human errors in a work system, especially those that can occur in interaction with machinery. By the application of Human Reliability Analysis (HRA) methods is then carried out the quantification of cases of human failure in the system.

- ***Mental Workload Assessment Methods***

  A mental workload represents a level of predispositions of a human to satisfy requirements imposed on the human. Quite a lot of such methods exist and they can be used widely in the evaluation of processes and also in the planning of them.

- ***Situation Awareness Assessment Methods***

  Situation awareness assessment methods are used for the analysis of human preparedness for situations that may occur in a system. They are used for the determination of requirements for knowledge and abilities of operators and machinery operators and are also a confrontation with the determination of target requirements for system functionality and quality of management preparedness in relation to the corresponding comprehension of formulation of individual operations and their interrelations. They are also used for planning the overall layout of the system. These techniques are used for partial as well as comprehensive evaluations of mainly dynamic systems.

- ***Interface Analysis Methods***

  Methods and techniques used for the analyses of interfaces in a system serve the evaluation and design and planning of requirements and functions of interconnections between specific elements of the system with a view to optimization, including the evaluation of e.g. worker satisfaction and consideration of worker opinion.

- ***Design Methods***

  They are the methods that are typically used especially in designing and planning new systems, activities and human factor relations in processes – of individuals, groups and sequences in the framework of large working teams.

- ***Performance Time Prediction Methods***

  They are used for the determination of corresponding time demands of work operations, tasks and activities, including the creation of designs of overall detailed overviews of work activities and scenarios.

- ***Team Assessment Methods***

  They are used for the assessment of performance of groups and teams for individual activities and also overall detailed overviews of work activities and scenarios. For such assessments, a whole series of aspects are usually specified and those are later assessed and compared. Requirements and the level of intercommunication, awareness, co-decision-making, load and co-operation are assessed.

Some Methods for the Evaluation and Optimization of Mental Performance

The supplementary above-mentioned methods can be applied in various phases of evaluation of work systems and can be used for their optimization as well. For the purpose of assessment of human mental performance and reliability in work systems, all groups are significant, because all respect the ergonomic approach to evaluation and design.

As for the group of ***Mental Workload Assessment Methods,*** they are e.g. the following methods: PTPM (Primary Task Performance Measures), STPM (Secondary Task Performance Measures), NASA method – Task Load Index (NASA-TLX), Bedford Scale or specified physiological measures [4, 7, 14].

- ***Primary Task Performance Measures (PTPM)***
- ***Secondary Task Performance Measures (STPM)***

  The primary and secondary measures are carried out on adapted simulators of specific conditions, e.g.: pilot, cars of various types, etc. In the primary part, the correctness and the time of control of a large whole are evaluated and scored, in the secondary part then individual sections and parts, including the levels of demands are set for application. The results depend on capabilities of software for this purpose, its rate of simulation of specific conditions and capabilities for the purposes of result evaluation.
- ***NASA – Task Load Index (NASA-TLX)***

  A multidimensional method of subjective evaluation. It is used for the comprehensive assessment of mental workload using checklists with pre-formulated questions by considering six categories: demand for mental activity, demand for physical activity, time demand, performance intensity, setting goals, frustration level. In each category, the answers of participants are scaled into twenty levels and evaluation is made by calculation of score in individual categories and subsequently of the total score.
- ***Bedford Scale***

  The multidimensional method of subjective evaluation. A simple checklist for subjective assessment of demand of execution of individual parts of the selected task. The scale of evaluation of mental demand is a ten-point rating scale, and subsequently the evaluation is carried out according to the acquired score as with the principally similar methods. Originally, it was developed for the evaluation of pilots and can be modified for other branches of activities; it is not too widely used.
- ***Physiological Measures***

  These are all methods that supplement, by means of precision measuring instruments for measuring the response of organism to simulated or real situations, a series of subjective

methods for the evaluation of workload during the set task. For the purposes of measurement, more positions of execution of the task can be usually set, and subsequently differences in organism responses can be evaluated. The methods are also suitable for verification of the competence of persons for specific accomplishment of the task and for determination of the duration of training. They are not usually appropriate for the setting of performance requirements for groups of people with different predispositions and experience. It is suitable to supplement the application of physiological measures with other methods, methods of task analysis and methods for subjective workload evaluation. The procedure of application is usually as follows: definition of the task for the purpose of analysis, selection of suitable measuring equipment, input test execution, selection of suitable participants, preparation and setting of measuring apparatus, including the setting of output parameters, pilot test execution, basic test execution, work with data and data analysis.

As far as the group of HEI methods (***Human Errors Identification Methods)*** is concerned**,** they are e.g. methods SHERPA (System Human Error Reduction and Prediction Approach), HET (Human Error Template), SPEAR (System for Predictive Error Analysis and Reduction), HEART (Human Error Assessment and Reduction Technique) [1],[2],[3].

The methods of Human Error Identification (HEI) are designed for predicting, ascertaining possible human failures in the work system, especially those that may occur in interaction with machinery. The application of the Human Reliability Analysis (HRA) method is then done for the quantification of cases of human failure in the system. In this group of methods, it is usually a case of combination of methodological taxonomic, identification and quantification approaches. The methods use the results of application of the Data Collection Methods, HTA (Hierarchy Task analysis), HEI and many auxiliary checklists.

- ***SHERPA (System Human Error Reduction and Prediction Approach)***

  The method was originally designed for process industrial applications, but it is applicable in any field of activity. It is a very thorough analysis of process used generally with a Hierarchical Task Analysis (HTA) in models or real processes, and is based on the systematic procedure for revealing possible failures and also the prediction of them. It is the most frequently used method and is mentioned as the most successful for error and failure prediction. The procedure of application is as follows: making of HTA, making of classification of tasks into five groups, making of HEI (error identification), making of HEI parallel analysis, comparison of the results of both done analyses, determination of error probability level, making of critical scale analysis, proposal for the minimization strategy, error elimination.

- ***HET (Human Error Template)***

  The group of evaluators will evaluate subjectively possible (according to their opinion creditworthy) errors and include them in twelve categories determined by the method (e.g. error in action execution, action incompleteness, erroneous setting, error of attached equipment, etc.). For each classified error, a precise description is then created (what was or can be done erroneously) and the error is subsequently evaluated according to the level of system failure severity. The method was developed for pilots and subsequently modified to be used especially in the aircraft industry. The procedure of application presupposes the following: making of HTA, HEI (error identification), parallel analyses, determination of error probability level, making of scaled critical analysis, making of attached device analysis (external influences).

- ***SPEAR (System for Predictive Error Analysis and Reduction)***

  The method was developed in the framework of evaluation of reliability of operators in the chemical industry in the framework of implemented (Human Reliability Assessment) programs. It enables the creative approach to application, contains the identification of environmental and situational failures. The typical application is associated with operators who use a large amount of controllers and accept a lot of information that has to be evaluated. Human failures (errors) are for the purpose of this method divided into five basic groups (as with the method SHERPA). This method can be applied in any environment. The procedure is as follows: making of HTA, making of subsequent subjective analysis, classification, sorting of ascertained errors by severity, making another analysis of each error, examples of solutions – minimization of generation, elimination. Tabular records of made analyses and resulting data are created.

- ***HEART (Human Error Assessment and Reduction Technique)***

  The method developed for nuclear power plants and chemical industry. It offers a possibility of numerical processing of data acquired by standard HEI methods with tabular, diagrammatic or descriptive outputs. The method generates the categories of tasks, conditions for error generation, causes of generation, possibilities of correction. Documentation for the purpose of inclusion in categories is necessary in a very detailed form. The procedure of application is as follows: determination of tasks or scenarios for the purpose of analysis, making of HTA (is not often sufficient and there is a need to supplement it with observation studies, controlled interviews, checklists), making of the screening classification of identified errors, assessment of classification reliability, selection of conditional error process, impact severity evaluation, identification of the possibility of error resolution and verification, procedure documentation.

Conclusion

Mental workload is not any uniform and one-dimensional term, and thus neither evaluation, nor measurement of mental workload can be a uniform process [14]. No single best method of ascertaining the mental workload exists; the most appropriate method of its determination and measurement depends on the purpose of evaluation that may require the determination of various aspects of mental workload, application of various measurement techniques and various degrees of precision. The determination of the level of mental workload is a basis for the further assessment of work systems from the point of view of their reliability, aimed at optimization, including prediction of human mental workload and reliability even in one-off and exceptional working conditions. Conclusions following from the analyses of mental workload and reliability of humans in work systems cannot be regarded as permanently valid; combinations of methods should be applied repeatedly with regard to changes in work systems and also to defined emerging psychosocial risks.

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