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Complex Approach of Work Safety Management Realization with Computer Support

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Subject review

Requirements of actual frame directions of European Union as well as national legal enactments demand realization of systematic activities within the scope of risk management, task is to export to market such devices which value of residual risk is from range of acceptable risk and finally realize steps of technical and human risk valuation in existing workplaces as well. These requests were starting impulse for members of realization team for development of knowledge system which is able to realize selected method of risk valuation as a part of preparation of production documentation realized by system of computer aid of technological preparation of production Sysklass. This solution realizes approach of concurrent engineering where together during product development can be realized steps which reveal errors which may later appear as source of unfavorable event in form of death, health damage, technical system or environment damage. Properties of proposed and created knowledge system predict its usage in both educational area during student training on our university and in technical praxis in environment of safety managing of smaller and middle-sized companies.

Kompleksni pristup upravljanju sigurnosti na radu uz računalnu podršku

Pregledni članak

Zahtjevi direktiva Europske Unije kao i državnih pravnih akata zahtijevaju realizaciju sistematskih aktivnosti u području upravljanja rizikom. Zadatak je ponuditi tržištu takve uređaje, za koje je vrijednost rezidualnog rizika u rasponu prihvatljivog rizika, i shvaćanje koraka za evaluaciju ljudskog i tehničkog rizika na postojećim radnim mjestima. Ovi zahtjevi su ponukali članove izvršnog tima za razvoj računalnog sustava znanja koji će biti u mogućnosti izvršiti evaluaciju rizika odabranom metodom u toku pripremanja proizvodne dokumentacije sa računalnom podrškom, pomoću programa Sysklass. Ovakvo rješenje objedinjuje pristup koji omogućava pronalaženje grešaka u procesu razvoja proizvoda koje mogu kasnije rezultirati neželjenim učinkom, npr. smrti, opasnosti po zdravlje, tehničkog oštećenja, ili zagađenja okoliša. Predstavljeni računalni sustav se može primijeniti u edukacijske svrhe za obrazovanje studenata, kao i u praksi u smislu rukovanja rizikom u malom i srednjem poduzetništvu.

1. Introduction

Work in safe work environment belongs to basic right of employees, guaranteed by present European and national's legal enactments. In countries of advanced world is injury, damage of health, work environment or technical system considered as cause of inappropriate management. Confirmatory fact of this statement is quantum of fatal and serious work injuries, where official statistics sustain death of 2.2 millions people per year worldwide [3]. However real number of this unfavorable statistic is even worst, this is mainly caused by certain abstinence of real register of work accident in less developed countries of the world. In connection with risk management of work there are several myths. Like for example that technological workshop – operation is dangerous, because of missing work accident register. Work injury origination is result of possible danger. It is necessary that employer in interoperation with employees execute all activities in frame of real risk management valuation on individual workplaces. It is important to realize that there is no absolute safety and

as relevant statistics show, main causes of unfavorable event creation are person's escapade, violation of working safety proceedings breaking of safety rules.

Area of work safety and health protection was according to section 137 of EC trade appended with wide range of arrangements. Basement of EU law regulations concerning work safety and work health protection is formed by frame direction with wide range of application, as well as other directions related to special concern of work safety and work health protection. These directions designate minimal requirements and basic principles, as for example principle of prevention and risk valuation, as well as designate liabilities of employees and employers. Area of machine safeness is covered by direction of EP and EC 2006/42/ES from 17th may 2006. Its revision was made by enacting direction 2009/127/ES which is effective for pesticide applying machines. Based on approximation of EU directives into national laws of member countries, in Slovak republic was this directive transformed in cabinet decree 436/2008, which established specification on technical parameters and method of machinery conformity valuation. Modern approaches in area of technical preparation of production demand not only design of operational and foolproof product but also device which will satisfy all actual specifications of safety, hygienic, ecology, fire safety and technical specifications. Methodology of risk valuation in process of machine design is adapted in technical specification STN EN ISO 14121-1 Machines safety, Risk Valuation, Chapter 1: Principles , from 2008 (which derogates specification EN 1050) and STN ISO 12100-1, 2: Machines safety – Basic terms, general principles of machine design. Chapter 1: Basic terminology, methodology and Chapter 2: Technical principles. Both were adopted in 2004. Adopting frame direction 89/391/ES, which concerns with proceedings for improving safety and protection of work health (further SPWH), changed meantime in many areas approaches and proceeding as well as philosophy of work protection. Basic principle of new SPWH policy is duty to valuate risks. This principle gradually framed into integrated safety theories and injury free prevention and actual these theories create new scientific branch – riskology.

2. Computer aid of risk identification and valuation and registration of industrial accident records system

Mention information act as impulse for development of complex system of computer support, which realizes selected methods of risk identification and valuation as well as registration of filed and registered industrial accident rate for time requested by legal rule.

In area of software application supporting process of risk valuation on workshops was in recent time remarked a great progress. Substantial post in Slovak environment has application environment BTS product of Be-soft a.s.. It integrates implementation of systems in area of work safety and work health protection, fire protection, protection of environment, civil protection and risk valuation. Main addition of this system is possibility of online update of software of work protection area according to actual directions [2].

CIRSMA™ represents software system of Industrial Safety Integration Company, created for risk analyses and determination of suitable methodology of risk restriction reflecting needs of enterprise environment. Application integrates system tools of risk identification and elimination in design phase of proposed system.

Area of serious industrial emergencies valuation uses software system ASSESS-RISK made by Fluidyn Co. ASSESS-RISK is based on UFTP (Union Francaise d'Industrie Petroliere) methodology and is a result of participant's exercises. The techniques imposed for risk assessment are based on qualitative methods, semi-quantitative criteria or quantitative. The basic approach is the evaluation of both the level of consequence and the associated level of probability. Here the consequences and the probabilities are divided into six categories. Different regulations consider the three levels of risk as lethal, destruction and irreversible. Risks are classified into four types, they are: risk due to toxic dispersion, risk due to over pressure, risk due to thermal radiation, risk due to missile effects [1].

Other software application, currently used in cooperation with system of quality control represent EtQ's Environmental Health and Safety (EHS) of ETQ - Excellence Through Quality Co. EHS is a flexible software package that guides companies through compliance with ISO 14001, ISO 9000, OHSAS 18001 and similar standards for environmental health and safety management.

Process of risk valuation and control on workshops can use whole variety of further software tools which are available on the market. Each one has its advantages and limitations. Some of these software solutions represent simple risk matrixes, other complex algorithms for determination of residual risk.

During development of knowledge system, main goal of realization team was creation of intelligent toll for process of risk valuation and work safety on workshops. In frame of concurrent engineering philosophy was its structure proposed in way, which the risk valuation process was applied in phase of product development in cooperation with systems of computer support of preproduction stages. It also contains method of risk valuation and determination of work safety for existing

workplaces. System uses inductive and deductive approach of risk analyses. Integral part of the system is module for work accident report. Direct integration into system of computer support of technical preparation of production this software represent original software solution among knowledge systems oh this category.

Knowledge system was developed with support of grant task KEGA (Cultural and Educational grant agency of Ministry of Education of Slovak Republic) No. 3/4135/06 "Creation of electronic educational materials for risk management in production technologies" with interoperation of results and conclusions of habilitation thesis realization of one from the authors of this paper as well as results and conclusions of undergraduate thesis elaborated on department of production technologies of Faculty of manufacturing technologies of Technical university of Košice with a seat in Prešov. This system represents custodial tool to system of computer support of technological preparation of production - Sysklass, on the ground of providing risk valuation results integration either on technological workplaces or newly created technological device to production documentation of part realized by this system.

On mentioned reasons following methods for identification and valuation were selected:

- Method of combined approach which partial consist of catalogue sheet method for risk identification and scoring method for risk valuation
- Method FMEA (Failure Mode and Effect Analysis) for error identification and risk exposure which may creates with error
- Method HAZOP (Hazard Analysis and Operability Study) for identification of danger of newly proposed, reconstructed and existing operations. This is flexible method which can be used at large continuous operations (for example petrochemical) but as well at small discontinuous processes and by independent device alike.

System realizes registration of centers and workplaces in target organizations of its usage and registration of industrial accidents records. Beside its primary functions system supports work with text editor with basic possibility of text formatting, application for e-mail and access to default internet web browser.

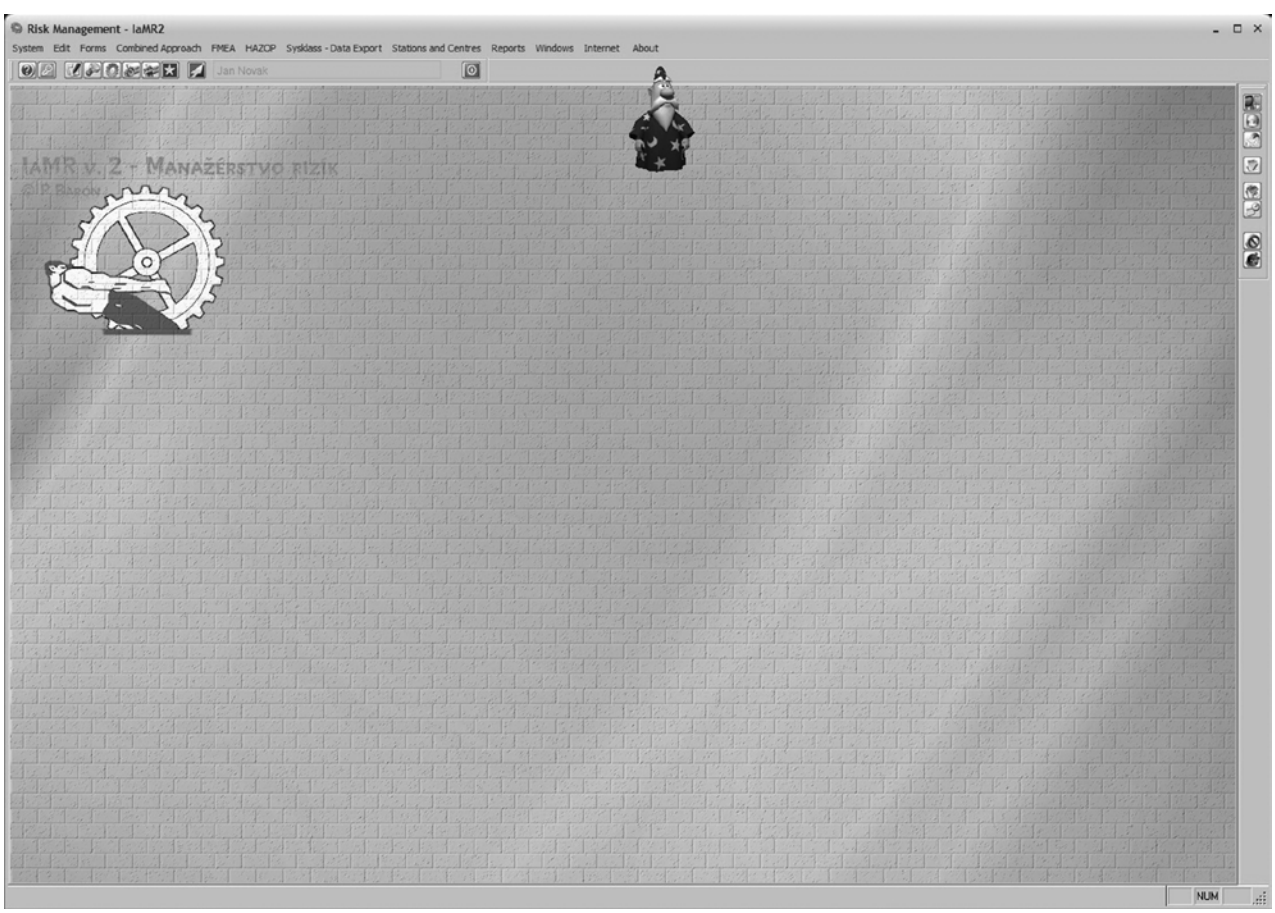

Figure 1. Environment of computer application for support and identification and valuation of risks and evidence of industrial accident records

Slika 1. Sučelje računalne aplikacije za identifikaciju i vrednovanje rizika, i evidenciju zapisa industrijskih nezgoda.

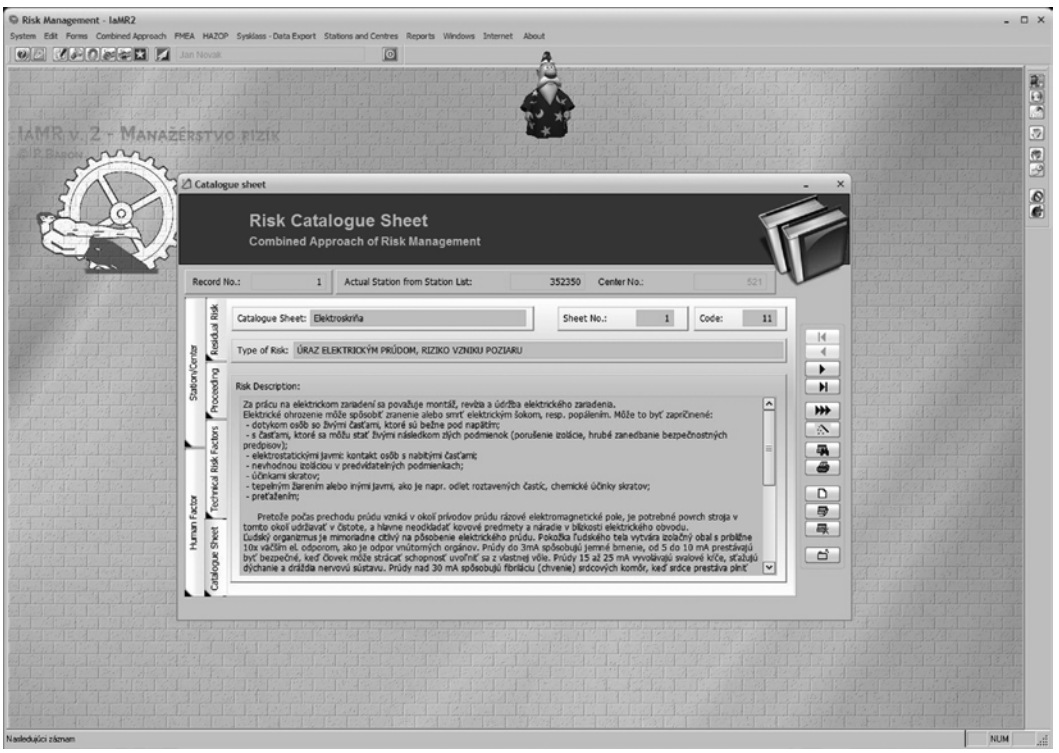

Figure 2. Catalogue sheets processing for risk valuation of functional segments of observed device

Slika 2. Procesiranje kataloškog lista za vrednovanje rizika funkcionalnog segmenta za promatrani uređaj.

3. System managing and user environment

Work environment of this application was developed similarly as classical software applications of Windows operating system. Access to dialog forms is realized through main items of system menu and thought icon buttons on toolbar (Figure 1).

Dialog forms contains container of bookmarks with text fields with relations to appropriate data in database tables, set of icon buttons for editing and moving among data records, filtering, sorting, deleting and adding of data entries. Application contains help which can be activated by pressing tab F1. Each chapter of help is bound with active form on the desktop. For quick orientation within application's environment is applied helper which describes user activity after clinking in question mark icon at dialogue forms..

4. Application of methods for risk identification and valuation

As usable tool for work safety valuation on observed workplace method of combined approach can be used. This procedure integrates all methods of Catalogue sheets for risk identification and risk factors with risk valuation using Scoring method.

Catalogue sheets represent two parameter record of causal dependency for set category of risks. They contain information about observed technical devices or segments of these devices. Catalogue sheets are used from design proposal of system (operation) till its disposal. Main goal of using catalogue sheet is quick recognition of danger in concrete operation. This means, it is necessary permanent filling of this list with new information during whole lifetime of technical system. This method is characteristic by its simple usage not demanding wide theoretical knowledge, but requesting enough practical knowledge of observed system. Risks identification with this method ensures operative interventions from level of lowest managing stages till level of middle management [4].

Form for realization of catalogue sheet evidence allows processing of requested information about risk through field placed on cards of container of form tab. Data are to final shape combined with usage of relation between data table with relevant information about workplaces and data table with risks identification and risk factors. Data in this form, like for example output result preview, can be filtered or sorted according to user's requests (Figure 2). Results are generated in form of print outputs of risk register summary (Figure 3).

After activation of form for calculating of scored value of risk is this activated with position of segments

of technical device selected in catalogue sheet form. Analogously there is a feedback between bought dialogue forms.

Scoring method is used for risk valuation in phase of preliminary analyses as well as in phase of detailed analyses [4]. For effective process of risk valuation is convenient assign exact value to concrete risk. Risk is therefore generally sensed as function at least two parameters, parameter of multiplicity or probability and consequence.

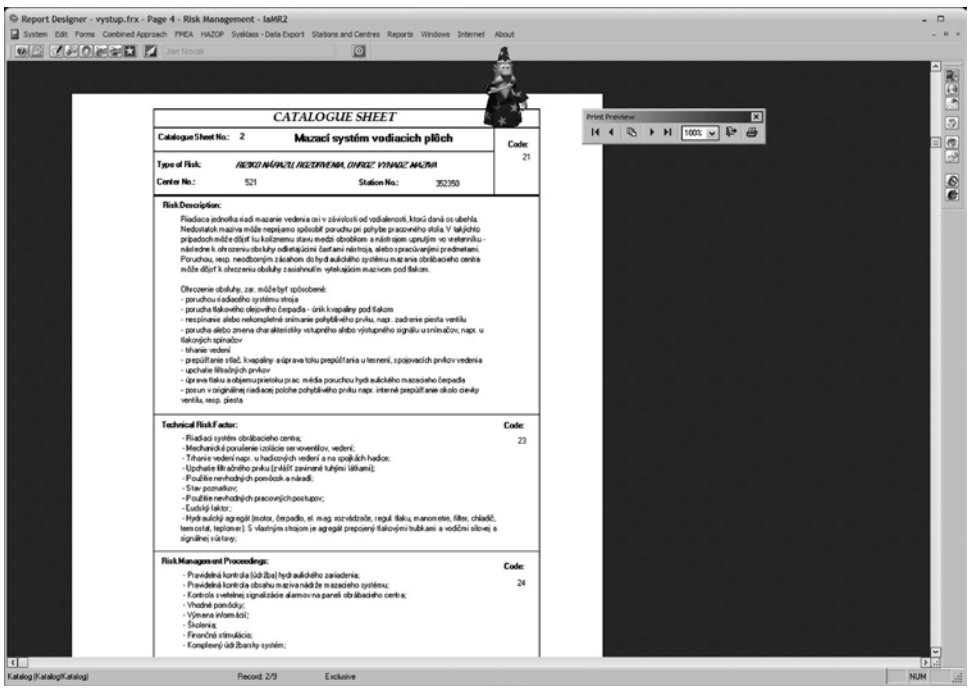

Figure 3. Configuration of print output of catalogue sheet

Slika 3. Konfiguriranje ispisa kataloškog lista.

Figure 4. Calculation of risk using scoring method

Slika 4. Kalkulacija rizika upotrebom metode bodovanja.

Estimation of probability of unfavorable event is very often determined upon statistic data of injuries or failure rate from qualified estimations of experts.

Consequence depends on:

- Range of damage
- Importance of damage
- Financial loss

Assigning value to combinations of probability and consequence of unfavorable event levels creates risk matrix. Scored value of risk is in range between 1 to 20 points. More lower the scored value of risk is than more urgent is realization of detailed risk analysis. During valuation of safety system is necessary to analyze non-acceptable conditions as well as devote acceptable ones.

In environment of created application, construction of risk matrix is realized by exact determination of probability and consequence of unfavorable event category from group of defined categories by selecting appropriate radio button particularly for consequence and probability. Pushing the "Risk Calculation" button risk matrix is designed – that mean determination of scored risk value what is connected with risk integration into classes from level Low risk to level High risk. Likewise responsible unit for correction measures is defined and pushing "Registration" button the name of user currently logged into system is allocated as a name of risk valuator in output summary (Figure 4).

To current most used methods for risk consideration and valuation certainly belongs FMEA method (Failure mode and Effect analysis). Development and usage of this method is connected with NASA's Apollo project in middle sixties on 20th century. Main goal of this statistic method is analyzing of probable errors occurrence and identifying their consequences of product's but also production process's and to propose correction steps for eliminations existing or possible errors. FMEA is method which allows identification of failures with significant consequences with influence on product function and process in considered application. It originates from characteristic of failure of basic part of product and from functional structure of system and set up relations between part failure and system failure, function failure operation restrictions and degradations of operability or compatibility of system [4-5] This approach can observe quality of construction of part but also analyze observed process of production (Design FMEA - Process FMEA).

In realized knowledge system is applied constructional FMEA with assumption of failure and risk identification of newly proposed parts and products with design changes of their production documentation realized by selected CAPP (Computer Aided Process Planning) system Sysklass. Reviewed design segment is divided into functional partial units with usage of block scheme. For each such created design segment is in knowledge system created data record. In dialogue form is beside identification fields of valuated segment presented analyze of error occurrence possibility, their causes and consequences for particular segment (Figure 5). At this point it is important to identify type of error, cause and consequence of error. Conclusions are made based on communication of design and technological team members and employees from production of observed part. Criticality of particular errors is qualitatively rated thru calculation of Risk Priority Number. Important part of this method is proposal of corrective steps for elimination of critical errors or decreasing f their occurrence and consequences. This action is followed by recalculation of risk number of observed part, after realization of corrective actions – very often in form of design, technological changes or increasing of quality controls.

In form for risk number calculation, reviewer pick coefficient from the list of coefficient of probability of error occurrence, weight of error a probability of error revealing. To each selected coefficient is in edit field allocated brief characteristics for exact identification. Pushing the *OK- risk number calculation* button will set area of proposed correction for retrieval realization – in case if calculated value of risk number is from range for which is necessary to execute corrective actions (Figure 6).

Design of output print report is drafted according to requirements of technical standard STN EN 60 812. This application of FMEA method is suitable as a foundation which allows valuating and ensuring failure free operation of products.

Last method of risk valuation of observed system which is supported by proposed knowledge system is HAZOP method (Hazard Analysis and Operability Study). Its development is connected with tragic industrial disaster of petrochemical operation in Flixborough (Great Britain) in 1974. Even though that risk identification is main goal of this method, it is necessary to realize that questions of operability should be also identified in regard that neglecting this also has tension of risk creation which consequence should be threat of health, system, environment or negative result on profitability usage of the system. During study elaboration, as well as by FMEA method, is system divided into logical, functional subsystems. Such division is always voluntary, where goal is creation of simplest subgroups with exact purpose. During this study a smaller group of experts elaborate critical valuation of the project (operation or system). Every partition and subsystem is valuated complexly with usage of keyword set. Keywords are in this method used so that members of the team can get immediate idea and based on they can identify probable divergence from proposed conditions. It is also very important to define

whether such conditions which may cause divergence exist. If yes, it is avoidable to examine their consequences [6]. Through combination of keywords and defining purposes of device nearly all patterns which may create divergence are examined. Such proceeding peg group of theoretical divergences from common purpose. Every one divergence need to be valuated and determined for possible consequences.

Figure 5. Dialogue form for identification of design unit errors realized with FMEA method
Slika 5. Dijaloški obrazac za identifikaciju grešaka pomoću FMEA metode.

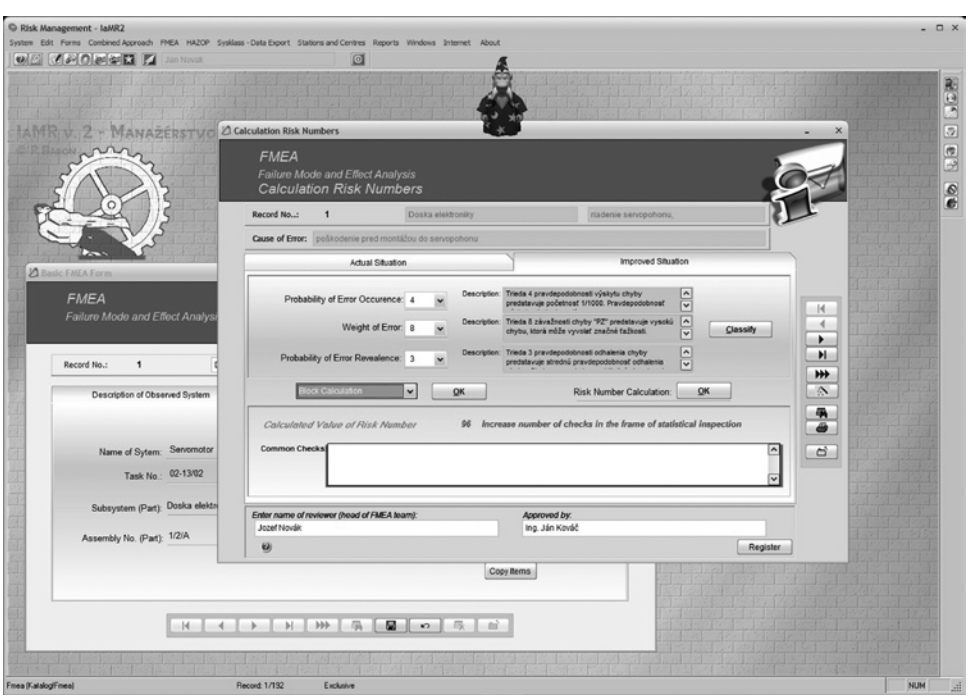

Figure 6. Dialogue form for risk number calculation of review segment
Slika 6. Dijaloški obrazac za izračun rizika promatranog segmenta.

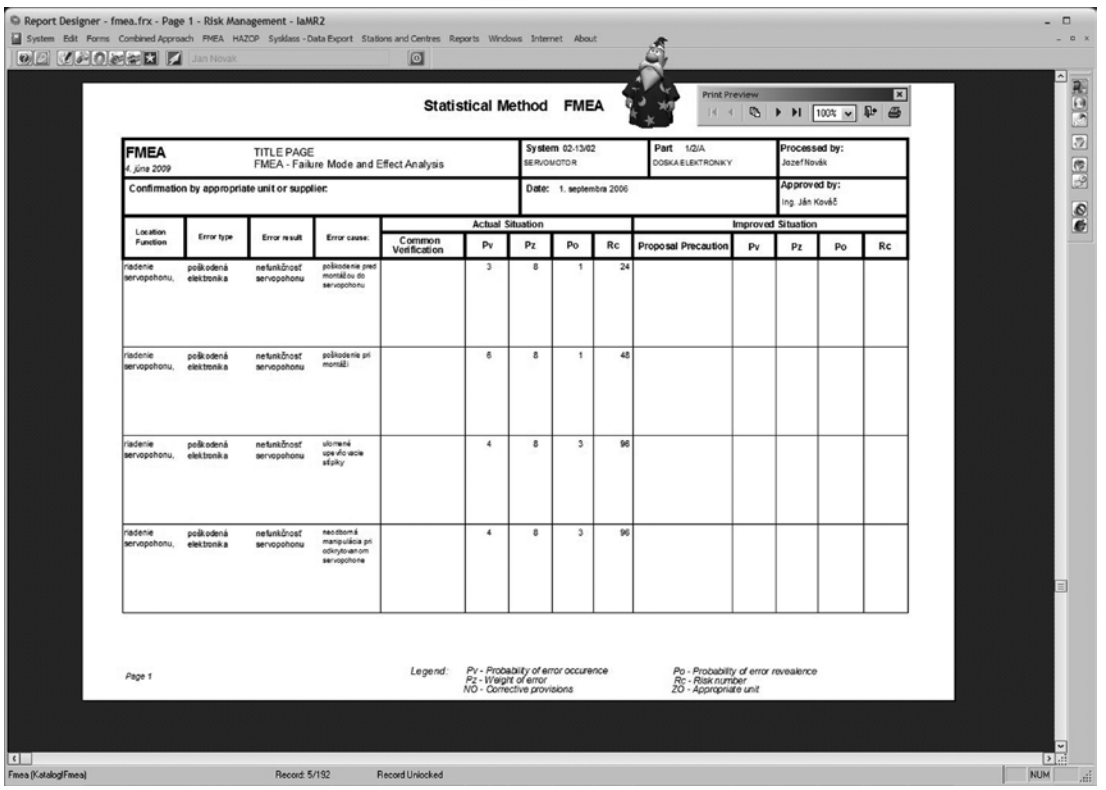

Figure 7. Processing of FMEA valuation results into output print summary
Slika 7. Prikaz rezultata vrednovanja metodom FMEA u ispisnom sažetku.

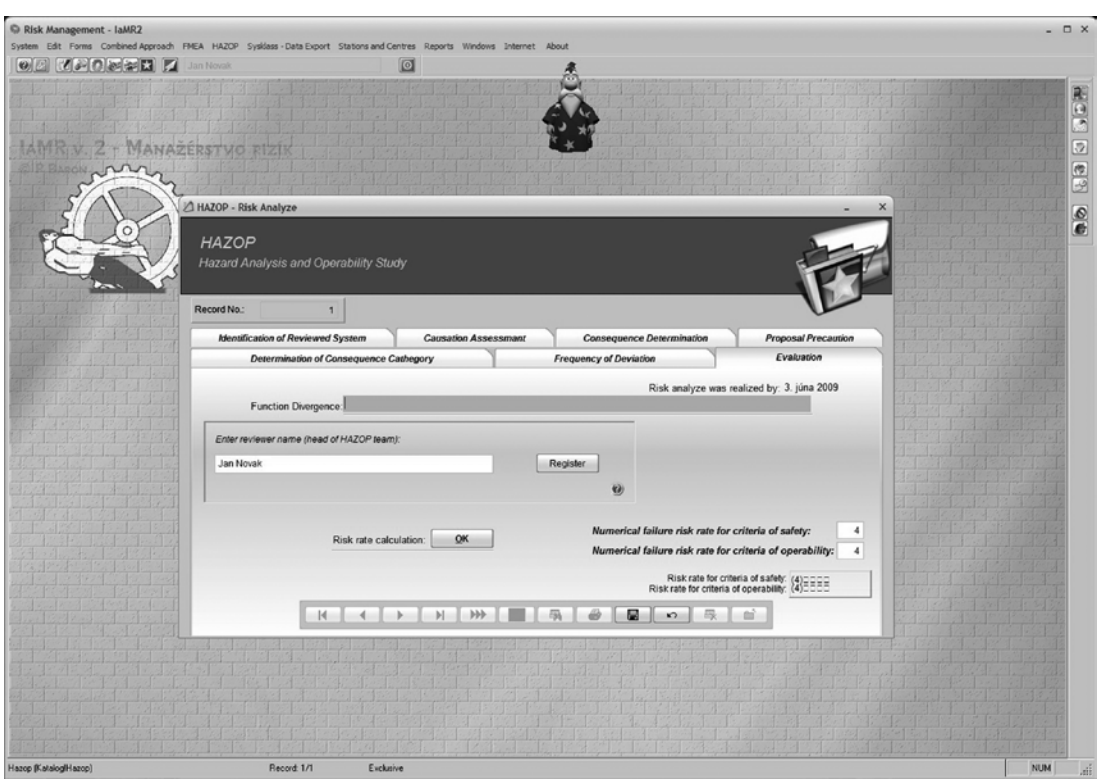

Figure 8. Application of HAZOP method in knowledge system environment
Slika 8. Primjena HAZOP metode u okruženju aplikacije.

In dialogue form of HAZOP method application assignment of consequence's category demands designation of deviation consequences of selected part function of observed technical device for criteria of safety and operability. In pop up menu is selected consequence – its characteristic is stated in editable field *Characteristic* Pushing the *Add consequence category* button in database table of valuated item with HAZOP method, field of criterion consequences is filled and this information is used by final determination of risk related with observed deviation of function. Similar approach can be used by determination of frequency of deviation as category of probability. For example selecting value 0,1 express that observed deviation is from range 0,9 to 0,1 times for observed period. Most common used period is 1 year. Tab *Evaluation* realizes determination of risk rate in case when rates of consequences and probabilities are set. Text field *Reviewer* contains name of user logged into system. In case of unlocking of computing module there is a possibility of changing name and assign it to data in database as a head of valuation team. Pushing the *OK* button computing of scoring rate of risk is realized. (Fig. 8)

5. Conclusion

Computer support of risk valuation opens new view on work safety, health protection and technical device safety. Enables automation of processes and modes eventuate in proposal and realization of preventive measures for achieving requirements of safe workplace. Globally it is necessary to realize:

- Every activity contain risks
- Safeness express accepting of certain level of risk
- Rate of risk acceptance changes according to technical, social, cultural level and according to results of science
- Risk handling includes risk valuation beyond law requests, not only fulfillment of legislation proceeding and standards
- Risk can be managed by technical, organizational and educational measures
- Analyze and risk valuation doesn't warrant absolute elimination of accident or system damage or work environment. That's why it is important in frame of corrective action elaborate proceedings and system of unfavorable events handling.
- Residual risk can not be regarded as acceptable risk
- About all possibilities of treat creation – even when chance is minimal, have to be informed all employees, users and personals whose are with this treat related
- Risk have to be manageable in all stages of development and existence of product in production process - manageable by creator
- Process of risk management must have system character and have to be part of work organization and employee's education.

Mentioned outlines represented impulse to realization team of proposed knowledge system for application of computer aided process of risk valuation, which lead to development of knowledge system processing narrow area of information from observed area through characteristic procedures. System was gradually upgraded according to requests on such tool evolving possibilities of industrial accident registration. Every database for typical sphere of valuated treats and errors can be exported into predefined forms of output reports or this export can also be done in form of tables of *.xls format. There is also support for generating of data archives and retrieving data records from these files. System also integrates CAPP system Sysklass. This tool can be activated directly from environment of knowledge system environment, so results of risk valuation processing of newly proposed can be directly implemented in production documentation. Such technique represents new approach in computer support of preproduction stages - commonly marked as concurrent engineering.

There are no exact rules for valuation of risks. Algorithm for risk valuation and recognizes steps for danger and treat identification, but in praxis these are often joint together. It happens that it may be useless complication to distinguish for example whether work with dangerous substance is danger or treat. Important is identification whether employees may be in danger or not. If valuation is made for selected system (machine, activity or work environment) main task is to identify conditions, characteristics, aspects which are possible cause of damage, accident or health treat creation.

Knowledge system is designed in compliance with present national and European enactment which demands application of valuation and risk management system in every stages of observed technical system lifetime, especially in stage of:

- machine design and planning
- machine productions
- machines operation and maintenance
- machines disassembly and disposal

Process of risk valuation of observed workplaces and technical systems is never ending process. In era of complex informatization of society described approach represent fully functional tool for risk valuation realization.

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