The Training of Electrical Engineers in Work Safety Management

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Abstract: The papers concentrates on presenting the necessity of introducing the training cycle for electrical engineers in Work Safety Management, while using an approach which, by analogy to TQM, could be referred to as TSM (Total Safety Management). Total Safety Management requires that among factors influencing formation of safe work conditions hazards should be identified and quantified as those that are beyond significant control by management, and as the ones that belong to the domain of the engineering staff. The above mentioned problem as perceived on background of the present Polish power engineering industry with particular consideration being given to the transformation process enables one to claim that identification and quantification of hazards in power engineering indicate a subjectively considered human factor as the most important element in work safety management in power engineering. The analysis of accident causes carried out in the study permits the hazards in power engineering to be defined, and based on this and on the existing models of safety management system. In this connection, a new program of training engineers within TSM relies on taking into account the subjectively treated human factor as an integral element of work safety management in the power engineering industry. In the new system of training engineers within TSM, a system of the weights of individual, both procedural and subjective, factors are introduced. These weights are capable of being determined owning to the introduction of a special matrix representation of the Total Safety Management system. The presented mathematical interpretation makes it possible to show to the students how to build new effective work safety management systems, not only procedural, but also subjective ones, where the subject of the system is a human

Keywords: TSM, identification, quantification, hazards, human

1. Introduction

The so-far undertakings in the domain of educating engineers were based on teaching how to format the safety conditions of work and had mainly practical character. The efficiency of this kind of action, to high degree, depends on the precision of recognising the factors, which condition the safety of work in the place of employment.

The group of factors conditioning the safety of work is usually very differentiated. Among these factors we can select a human factor, a material factor and organisation. The identification of the influence of these factors and their interaction involves complex scientific surveys, which have to concern both: the human factor and equipment / methodology of work and their mutual influences. The importance of this matter on the world scale is proved by the wide range of scientific surveys concerning the human factor in the process of work, which was formulated as the complex system, which elements such as the human factor, technical object and the surroundings or of the same importance.

The safety of work is the problem of particular importance. It has different determinants. One of them is a political one, resulting from activities, which lead Poland to joining the European Union. Another one is a social determinant as an effect of the lost of health by victims of accidents. Next is an economical determinant, which includes costs of medical attendance, disability pensions and losses as a result of disturbance of the process of work in the company.

Owing to the rapid social and economical transformations taking place in Polish econo my in recent years, the need to incorporate the safety of work matters into theory and practice of total management in every company is entirely justified. Thanks to proved economical and organisational connections these issues have as well important function for management and engineering staff - the need to produce the high quality products, achieving optimum (in given conditions) efficiency of work, or lowering personal costs with simultaneous respect for the environment of work.

Numerous observations, surveys and analyses in the range of accidents at work and circumstances in which they arose, assure about the existence of dependence between accidents and the system of work safety management. The problem of safety and hygiene of work is especially important in the time of political transformation, i.e. during the time of the system of property changes.

The safety of work also profitably influences the whole image of the company. In front of the proceeding process of privatisation it directly influences the value of the company.

The so-far existing „ways of organising the safe work" appeared to be not sufficient. Increasing scale of threats and the size of their effect extorts currently wholly different approach towards problems of safety. In result of that the conception of the safety management was introduced and subsequently the system of work safety management

Considering the system's approach towards the issues of the Safety and Hygiene of Work management, the most important was that among factors which influence the creation of the conditions of work in the company are as well the factors on which the company has no bigger influence. Creation of fully safe conditions of work involves proper organisation and multidirectional actions on every level of management of company and besides the existence of the system, which through the analogy with TQM we can call TSM (Total Safety Management).

This form of education is based both on own research of the authors and other, which are carried out in particular organisational units of power industry.

As the result of the research, it was found that identification and quantification of the threats in power industry allows to indicate a subjectively treated human factor as the crucial element of the model of work safety management in power industry

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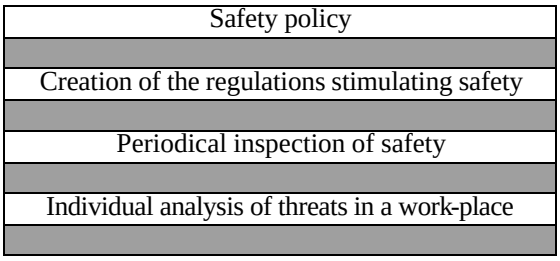
2. Education in the range of work safety management in reference to power industry

Referring to introduced in the previous subsection periodical character of integrated model of quality management, the Safety and Hygiene of Work and environmental protection we can in similar way show the procedural model of work safety management in power industry (scheme 1.).

Estimating the showed above the procedural model, which illustrates the cyclical character of the System of Work Safety Management, we can conclude that the human factor is there treated subjectively. However, electrical industry is a very specific department of economy, in which consideration of subjectivity of the human factor is one of the most important, if not the most important, element of the System of Work Safety Management.

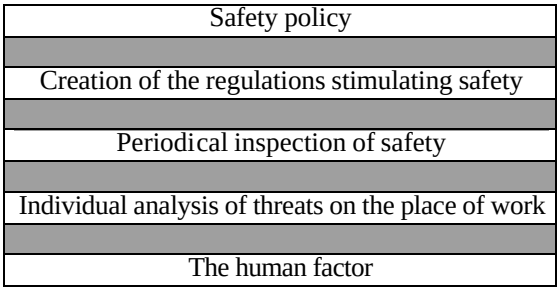


Scheme 1. The procedural model of the work safety management in electrical industry.

Consideration of identified threats in energetic industry and their quantification allow to state very precisely the connections between the human factor and elements of the environment of work and its organisation.

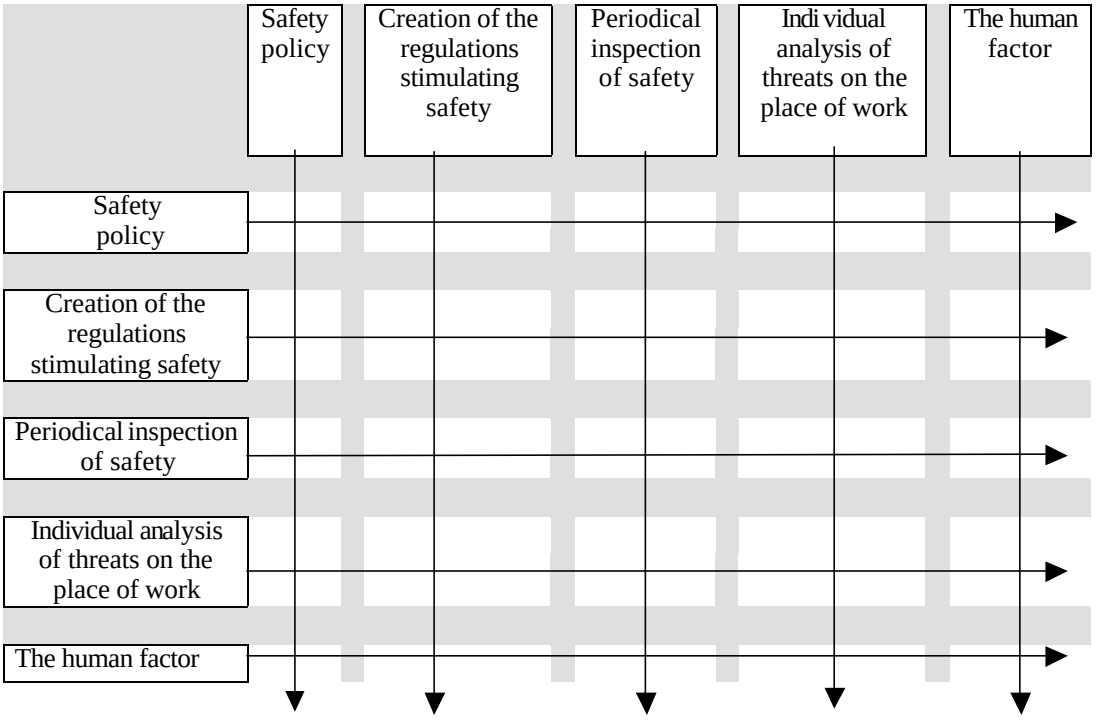
The model of these connections and mutual relations between materials, social environment of work, conditions of work organisation in a work-place and human physical, mental and psychophysical features and chosen elements influencing these features in the process of work, as well as particular environment's elements, in which the work process occurs, are also of a great importance.

Considering all of these conditions we can conclude that efficient work safety management can be achieved by a creation of a procedurally-subjective system, in which a human being is the subject in conditions of work and in that direction engineers of electric industry are educated.



Scheme 2. The block scheme of work safety management with the human factor.
Source: Own elaboration.

It is not enough to issue regulations, which indeed indicate the aim and the way of achieving it, but are not able to start in the company the functioning of the system of workers protection. The education of the future electric engineers is necessary in the modern organisation of the safe work, according to the demands of ergonomic utilisation of the latest achievements of technology, organisation and training.



Scheme 3. matrix model of the management of the safety of work in engineering- the generalised shape

In the process of education the theoretical basis of the system of the work safety management and indications of definite propositions of structural and functional changes are defined, and this allows to increase the efficiency of work safety management as a whole. The system analysis can be done algebraically.
General matrix scheme of the system' s structure record can be shown as a matrix.

3. Dangers as identification functions

With use of matrix system of elements and streams it is possible to introduce danger f_{ik}, created by certain elements D_i and controlling the flow of subjective streams s_{kl} as identification functions. There are:
identification z_{ki} from subjective elements,
identification d_{ij} from other procedural elements.

Table 1 Matrix system of elements and both procedural and subject streams in work safety management system in power industry

	W	W	W	W	W	W	D_1	D_2	D_3	D_4	D_5
D_1	f_1	f_1	f_1	f_1	f_1	f_1	0	d_1	d_1	d_1	d_1
D_2	f_2	f_2	f_2	f_2	f_2	f_2	d_2	0	d_2	d_2	d_2
D_3	f_3	f_3	f_3	f_3	f_3	f_3	d_3	d_3	0	d_3	d_3
D_4	f_4	f_4	f_4	f_4	f_4	f_4	d_4	d_4	d_4	0	d_4
D_5	f_5	f_5	f_5	f_5	f_5	f_5	d_5	d_5	d_5	d_5	0
W	s_{11}	s_{12}	s_{13}	s_{14}	s_{15}	s_{16}	z_{11}	z_{12}	z_{13}	z_{14}	z_{15}
W	s_{21}	s_{22}	s_{23}	s_{24}	s_{25}	s_{26}	z_{21}	z_{22}	z_{23}	z_{24}	z_{25}
W	s_{31}	s_{32}	s_{33}	s_{34}	s_{35}	s_{36}	z_{31}	z_{32}	z_{33}	z_{34}	z_{35}
W	s_{41}	s_{42}	s_{43}	s_{44}	s_{45}	s_{46}	z_{41}	z_{42}	z_{43}	z_{44}	z_{45}
W	s_{51}	s_{52}	s_{53}	s_{54}	s_{55}	s_{56}	z_{51}	z_{52}	z_{53}	z_{54}	z_{55}
W	s_{61}	s_{62}	s_{63}	s_{64}	s_{65}	s_{66}	z_{61}	z_{62}	z_{63}	z_{64}	z_{65}

Source: authors' own calculations on the basis of [1], [2].

Property of matrix notation used in this example allows for identifying all connections – as far as input and output are concerned – for each element.
As a conclusion one may say as follows:
Dangers resulting from the lack of safety policy (D_1)

$$\phi_{11} = f_1(d_{12}, d_{13}, d_{14}, d_{15}, d_{21}, d_{31}, d_{41}, d_{51}, z_{11}, z_{21}, z_{31}, z_{41}, z_{51}, z_{61}) \quad (1)$$

Dangers resulting from improper regulations (D_2)

$$\phi_{22} = f_2(d_{21}, d_{23}, d_{24}, d_{25}, d_{12}, d_{32}, d_{42}, d_{52}, z_{12}, z_{22}, z_{32}, z_{42}\, z_{52}, z_{62}) \quad (2)$$

Dangers resulting from the lack of periodical service (D_3)

$$\phi_{33} = f_3(d_{31}, d_{32}, d_{34}, d_{35}, d_{13}, d_{23}, d_{43}, d_{53}, z_{13}, z_{23}, z_{33}, z_{43}, z_{53}, z_{63}) \quad (3)$$

Dangers resulting from improper threat analyses on work position (D_4)

$$\phi_{44} = f_4(d_{41}, d_{42}, d_{43}, d_{45}, d_{14}, d_{24}, d_{34}, d_{54}, z_{14}, z_{24}, z_{34}, z_{44}, z_{54}, z_{64}) \quad (4)$$

Dangers caused by a human factor (D_5)

$$\phi_{55} = f_5(d_{51}, d_{52}, d_{53}\, d_{54}, d_{15}, d_{25}, d_{35}, d_{45}, z_{15}, z_{25}, z_{35}, z_{45}\, z_{55}, z_{65}) \quad (5)$$

Such model of managing work safety is profitable for introducing it in structures of integrated information systems in power industry. One of the reasons is that such model allows to describe danger and establish weights for certain elements according to their volume of influence.

In the presented model authors assumed that so far described procedural models represented by elements grouped in modules D_1, D_2, D_3, D_4 created work factor and procedural part of the model. The last module D_5 is a human factor and proposition to extend model about subjective factor.

Correctness of the model structure can be checked in the following way:
procedural – subjective model is built on procedural part marked in matrix notation as streams D_1, D_2, D_3, D_4 and subjective part, where the subject is a human being, which is illustrated in matrix as stream D_5.
It is possible to conclude

$$M_{pp} = D_1 + D_2 + D_3 + D_4 + D_5 \quad (6)$$

Where

M_{pp} means procedural – subjective model.

If all elements of the model appear in the procedural – subjective model of managing work safety then such equations are achieved:

$$M_{pp} = 1 \quad (7)$$

$$D_1 + D_2 + D_3 + D_4 + D_5 = 1 \text{ dla } D_i \in [0; 1] \quad (8)$$

And then we can write

$$D_5 = 1 - (D_1 + D_2 + D_3 + D_4) \quad (9)$$

In the above equation there is a need to describe weight of D_5. The aim is to avoid solving equation for very small values of D_5, so model is correct for such D_5 which value is not smaller than average value of the rest of the factors ($D_5 \geq 0,2$).

Procedural – subjective model of managing work safety in power industry is correct when weight of the human factor represented in matrix model as D_5 achieves value not smaller than 0,2. This weight can be calculated from basic causes of accidents, which means from the work factor (which includes both elements: procedural and human).

4. Conclusions

In the recent years Polish power industry has been subject to global reorganisation, and that is for environmental reasons and adoption to the EU standards. Market economy creates possibilities for competition in all sectors, also for those that have been state owned so far - like power industry.

Education of electrical engineers requires new approach to management issue and especially to work safety management in the form of Total Work Safety Management System. Education in this direction requires such conditions like avoiding cost connected with accidents, improving company' s image, which is especially important in strong competition market. One of the very important conditions is requirement from the EU, which does not allow to sell so called "dirty energy", i.e. energy produced against regulations in the fields of environmental protection and work safety.

5. References

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