HUMAN FACTOR ANALYSIS IN THE RISK MANAGEMENT IN TECNOLOGICAL PROCESES AND IN A GLASS PRODUCTION PLANT

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ABSTRACT

The role of the human factor in the process of accident development has been a major accent in the process of risk assessment from the last 20 years up to now, after the development of some of the most severe accidents in the human history (Sevezo, TMI, Chernobyl, etc.). The human factor - human failure and human behavior could have either positive or negative impact on an accident. It can contribute its development, by taking actions in deviation with the ones, required by the process standards, or decrease its negative effect and save lives by timely and appropriate actions. The human failures are divided on non-intended errors-skill based errors (slips of action, lapses of memory) and mistakes (rule-based mistakes and knowledge based mistakes); and intended-violations (routine, situational and exceptional). Using the Method of Organization, systematization and analyses of risk – MOZAR, a glass production plant had been divided into three subsystems - scanned for threats and were developed scenarios for the most likely to happen incidents. One of the scenarios (a gas explosion) is presented by a fault tree analysis. It is seen that the human factor (here considered as human failures) takes a significant part in the accident development. The human failures are described in detail, as a key component in the realization of accident scenarios in the plant.

Key words: *Human Factor Analyses, Risk Management, MOZAR*

The focus on the human factor and its contibution for the realization of major industrial accidents had been drawn on, after the happening of key major accidents (Sevezo 1976, TMI 1979 Chernobyl 1986, etc.), which are symbols of the critical manifestation of the human factor-human failures. The human failures could be found both in the process of technological development of the destroyed equipment and as part of the human behaviour in the control room. During the last 20 years, the study of the human failures and the human factor in general, as part of the Analyses of the human reliability in the management of the technological processes and risk management, bacame more nad more popular [1÷5]. Today the technological processes are at their most part, automatic, but despite the apparent lack of directly involved in the process people, one material system is not able to be built in itself, nor is fully operable independently, or able to maintain and reconstruct on its own yet. Therefore, in the search of the reasons for the accident to happen, the direct or indirect human failure will always be the object of study.

The human behaviour at the accident development proceses can occur in several ways [5]:

Table 1-Human participation in the accident development processes

Description	**Human involvement**	**Results**
Wrong behavoiur	Actively involved	Negative
Wrong desisions	Actively involved	Negative
Misinterpretation of the a situation	Actively involved	Negative
Working environment-as a prerequisite of hum.failure;	Passive	Negative
Right behaviour in s critical situation	Actively involved	Positive
Taking the right step to mitigate the consequences	Actively involved	Positive
Actions towards avoiding an accident	Actively involved	Positive

The methods of analysis and assessment of human reliability, require the human factor to be considered as a separate element which must be precisely defined, measured and managed effectively as part of the overall process of analysis and management of risk. The emergency planning and training, the risk assessment and the technical safety, concerning every technological process, can minimize the actively involvement of people in the development of accidents and increase the chances of preventing them.

The purpose of this report is an analysis of the human factor in the management of the technological risk in general and specifically for a glass production plant in "Inhom" Factory - Beloslav. For this purpose, would be used the **M**ethod for **O**rganization, systemati**Z**ation and **A**nalysis of **R**isk-MOZAR [2], and the matrix of human failures, describing the main types of human erroneous actions [5].

In the glass plant the glassware is made by hand, there is also a semiautomatic production with a robotic arm, press and centrifugal molded glass products. The plant scheme includes: *Material compartment bunker*- automatic weighing machines, conveyor belts, mixers; T*ub furnace*, operating in a temperature of 1400^0C, 4 pcs. gas burners; *Temper tunnel furnace*, operating in temperature of 550^0C, 8 pcs. gas burners; *Gas installations*; *Air tubes with fans*;

Following the **M**ethod for **O**rganization, systemati**Z**ation and **A**nalysis of **R**isk-MOZAR the plant had been logically divided in three sub systems, which are scanned for threats and there were developed scenarios for the most likely to happen accidents, which are: A leakage of hot molten glass substance through a break in the tub furnace; Fire; Explosion, while tempering (heating) the tub furnace; Explosion while heating of a tunnel furnace; Disposal of refractory pieces from the both furnaces, in case of their explosion. As most likely to happen incident scenario is the one which happens, while tempering a tub furnace with a subsequent shutdown of the gas burners when the temperature in the oven has reached 450-500 ^{0}C. After an attempt to re-ignite the gas burners (a presence of an ignition source) is obtained an explosion. This scenario was developed in the Fault Tree Analysis. (Figure 1).

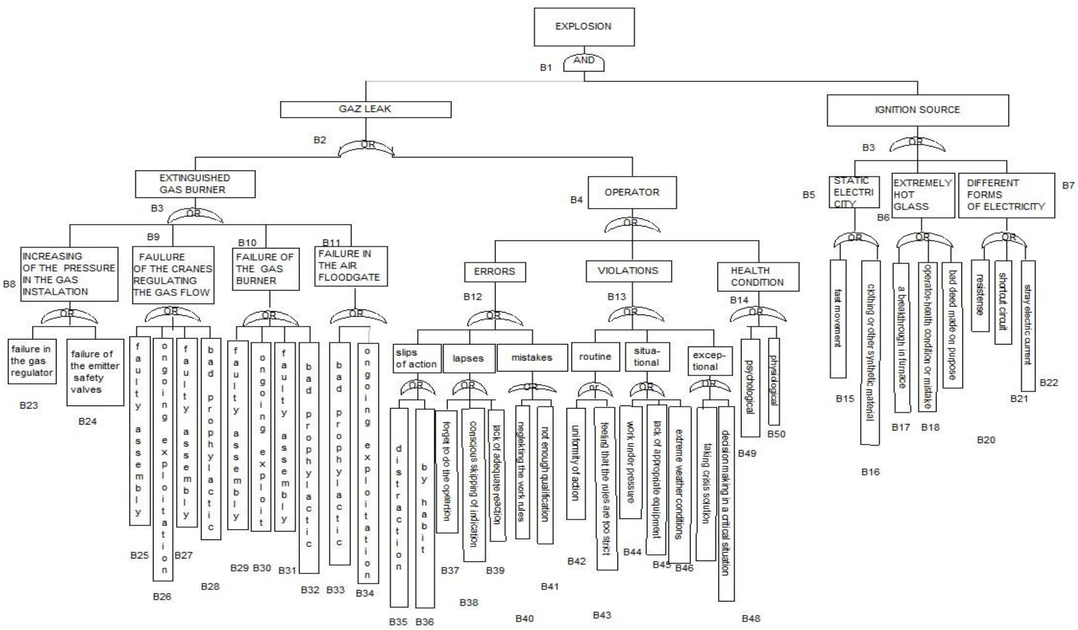

Figure 1- Fault Tree analysis of Scenario: Gas explosion in a glass furnace while its temepring

The matrix of a human failure - describing the main types of human erroneous actions - Fig. 2., is a part of the fault tree (outlined in Figure 1) for every scenario and despites the various types of scenarios, this matrix is always present and completely the same. For the sake of clarity, when presenting the human factor (the operator performance) in the fault tree analysis we added a branch which describes the human health conditions, although they might be included as a cause of the so-called unintentional errors-slips of actions and lapses.

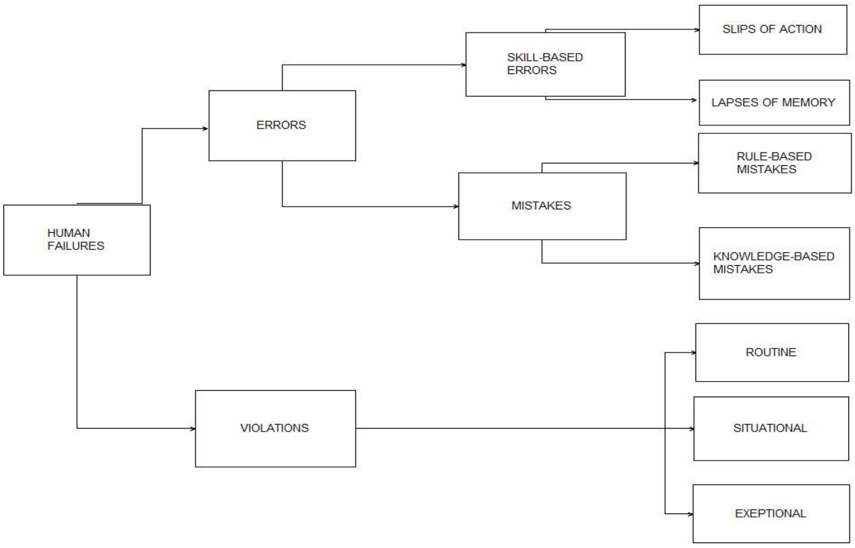

Figure 2. Human Failures

The human failures are divided into two main types: **error** – not intended action or decision that deviates from the accepted standard and leads to the development of an accident and **violation** - intentional deviation from a rule or procedure [5]. The errors are divided in skill based errors and mistakes. The slips of action is a skill based error, which happen, when an operator is pretty well acquainted with an operation and develop it "by habit", without any additional attention on it. These errors are very unlikely to happen on a first sight, but despite their apparent security, the human factor in this situation is very sensitive to every inaccuracies caused by even a momentary distraction. The lapses of memory happens, when an operator is losing its place in a operation, or even forget, what he/she had intended to do. Mistakes are more complex types of human error because it involves processes of planning, evaluating information, formulating plans and impact assessments, or the operator does something wrong, believing that he is doing something right. There are two types of mistakes: Rule-based mistakes-the operator's behviour is based on a memorized rules and well-known procedures; Knowledge based mistakes- the operator takes a conscious decision in a situation of unknown or unfamiliar circumstances. Violations are every intentional deviations from the work rules, procedures, ihnstructions and regulations. These human failures are very serious reasons for many accidents, which happen on the work place. The violations are divided in three basic branches: routine, situational and exceptional. The routine violations happen, when there is a normal work regime within a normal work environment. Situational violations happen for reasons, coming as a result of the work situation for example work under presssure, not enough people to work at the site, overloading with work duties, lack of the right equipmentor even extreme meteorological conditions. Exceptional violations- gathering on one place of some nagative factors, which are causing as a results a new problem, which requires a crysis desician, breaking some main rule.

The real manifestation of the human failures for the development of Scenario "Gas explosion of a glass furnace while temepring " has been listed in table 2.

Table 2: Real manifestation of the human failures for the development of Scenario "Gas explosion of a glass furnace while temepring ".

	Specification	Execution	Leads to:	Barriers	
				Technological	Organizational
ERRORS	Skill based error	Distraction, while reading the tmperature of pressure	Exceeding the permissible values	All important devices or alarms are situated in the working vision area	To eliminate external factors (noise, light, etc.).
		Operator is working "by habit"	Pressurizing in the furnace or gas installation	Light and sound indication when exceeding the parameters of the required values	The execution of the actions could not to happen automatically
					The concentration of the operator to be always at a high level in any activities (operations)
	Lapses of memory	Foget to do an operation	Turning off the gas burner, creating conditions for explosion	Providing effective reminder lists, signaling prominently	
	Lapses of memory	Misreading of an indication (on purpose)	Development of a critical situation in terms of induced value - level of molten glass substance, T, P	Improving of signaling and communication	In performing activities (performing repeatedly for a long time) the operator verifies if any parameter has been changed
	Lapses of memory	Missing (lack) of adequate reaction	Not properly led technological processes	Removal of distracting irritants	Improving of the qualification (effective training regime under stress)
	Rule-based mistakes	Ingnoring of the work instructions	Change the required parameters at the discretion of the worker	Providing of an adequate supervision of both inexperienced and experienced operators	Training the staff with their obligations and actions to be performed during the manufacturing process
	Know ledge -based mistakes	Not enough qualification	Not folowing of the technological process plan	Indicators for the completing of every technological phase within the process	Hiring of trained people for the task or training of less qualified people to work
VIOLATIONS	Routine violations	Uniformity of actions	Skipping a phase in the technological process – not feeding with glass stock		More frequent but short breaks
	Routine violations	Feeling that the rules are too strict	Over passing the parameters of the process. The temperature increasing for shortening of the process for example.	Indicators for the completing of every technological phase within the process	Expaining the staff, for the reasons these rules are required;
					Revision of the rules, in case there are unnecessary rules or procedures to be replaced with new, more readable ones
	Situational violations	Work under pressure	Deliberate violation of instructions to shorten the process, or savings	Indicators for wrong execution of the process	Reducing of the pressure on the working staff
	Situational violations	Lack of the needed (right) equipment	Equipment with wrong paremeters-fans, pipes diameters	Equipment, required for the right process development	Prohibition of the use of inappropriate equipment.
	Exceptional violations	Taking of a crysys desicion	In case of accidental power failure, turning off of the gas burners in full oven	Duplication of power	Training for action in crisis situations
	Exceptional violations	Taking of a decision in a critical situation	Work in terms of a natural disaster or if human lives are endangered	Possibilities for terminating the process when needed.	Training for action in crisis situations

Conclusion: The Human factor studied here in his manifestation as improper human activity is present strongly in each technological process. Represented as a matrix, in the Fault Tree analysis developed within MOZAR, the human behavior has a key place. For all five scenarios concerning the accidents in the studied glass plant, the elements of the matrix presenting the human failures are the same, and the barriers –the technological or organizational measures, taken towards avoiding the incident (the top event in the fault tree) are identical. The assessment and the management of risk by assessing and managing of the critical manifestation of human factor can prevent different scales of accidents, minimize losses, save resources and save lives, therefore the human factor should be treated as a separate element of the risk, should be clearly defined, measured and managed effectively.

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