STUDY ON REDUCING ACCIDENTS CAUSED BY THE HUMAN ERROR IN THE MINING FIELD

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Abstract: In this paper applied the theory of human reliability in activities carried coal mining. After the definition of human reliability and terms that quantify qualitative or errors and their causes of occurrence are presented: the important factors affecting the performance of human operators; factors leading to increased stress human operator mining.

Keywords: human factors, reliability, error, failure, performance.

1. INTRODUCTION

Failure of engineering systems is caused not only by the malfunction of the system itself, but also by human errors. In reality, human reliability plays a crucial role throughout the lifecycle of the system: in the design and development stage; during production or execution stage; work or running stage (mining operation).

The origin of the human factors history must be sought in 1898 when Frederick W. Taylor performs different studies to determine the closest description of the influence of the excavator workers' activity. In 1958, Williams admits that the human operator reliability should be included in the overall system reliability prediction; otherwise such a prediction would not be realistic. In 1960, Shapero' work strongly supports the importance of the human reliability in the systems engineering by emphasizing that the human error is the cause for equipment failure rate of 20 to 50 %. In 1962, a database known as 'Data Store' which contains timing and performances in predicting the reliability for the human engineering, established the main features of human reliability. Moreover, in 1960 there were two scientific sessions on the human reliability/human error. In 1973, IEEE Transactions in Reliability publishes a special

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paper on the human reliability. In 1980, a selective bibliography on the human reliability was published, covering the period from 1958 to 1978. The first book on the human reliability appeared in 1986 and was entitled *Human Reliability: on the Human Factors*.

2. DEFINING HUMAN ERROR

There are many terms and definitions used in the field of the human reliability, some of which are listed below.

Human factors. This is a main part (base) of the scientific realities on human features.

Human error. This is a failure, carelessness in carrying out a given task (or stop an action performance) that could result in disruption of certain planned operations or the damage of features or equipment.

Human Performance. This is a measure of the human actions/human work subject to specific conditions.

Permanent tasks. This is a task involving a certain type of activity; for example, monitoring a changing situation.

Human reliability. This is the probability of achieving successfully of a task by the human operator at any level required by the functioning of a system in a period of time (if such a set period of time is required) and in certain given conditions.

3. THE OCCURRENCE OF THE HUMAN ERROR. CLASSIFICATION, TYPES AND CAUSES

Human errors can occur in various distinct types, and it follows below.

Thus there are: errors of decision; errors of action (intervention control), transmission errors; error checking (supervision); diagnostic errors; reducing errors (retrieval).

Errors occur when a decision is made after considering the situation.

Errors of action (intervention) result in non-application, driving incorrect or correct course of action on a wrong target when it exists.

Transmission errors occur when the information to be sent to others is not transmitted, or transmitted incorrectly, or sent to a wrong destination.

Verification errors (control) exist when systems require checking when incorrect attempts are made when attempts are omitted, or when attempts are made to correct incorrect objectives.

Diagnostic errors are the result of misinterpretation of the current situation when an abnormal event occurs.

Reducing errors occur when any of the individual memory or any other reference source is not received or incorrect information is received.

Human errors can be classified into several distinct types as follows.

Design errors. These errors are the result of poor design. The causes of these errors are inappropriate allocation functions of human operators, failure to implement human needs in design, failure to ensure effective interaction between man and machine, etc. An example of a design error is the location of recording equipment and monitors so far that an operator cannot be used in an appropriate manner.

Operator errors. These errors are the result of human operator errors. The conditions that lead to operator errors include lack their own procedures (specific) complex tasks, selection and inadequate training of staff, poor conditions of the environment, and negligence (carelessness) of the operator.

Assembly errors. These errors occur in the process of assembly of the product. Assembly errors occur due to factors such as low levels of the design work, inadequate lighting, excessive noise, poor copies of the drawings or similar materials, excessive temperature in the work area, and inadequate communication of information.

Inspection errors (examination, checking). These errors occur at less than 100% due meticulousness or accuracy of the inspector. An example of inspection error (check) is the acceptance or rejection of components located outside or within the specified tolerance.

Maintenance errors. These errors occur because of negligence or omissions of the staff in charge of maintenance. If the equipment is old, the probability of occurrence of these errors may increase due to the increasing frequency of making the maintenance. Some of the maintenance errors are the improper calibration (calibration, tarring) of the equipment, the use of improper lubricants, the improper repair of the damaged equipment.

Installation errors. These errors occur due to several factors including the use of improper installation on the instructions or copies of the documentation, or the simple mistake of installing the equipment in accordance with manufacturing specifications.

Handling errors. These errors occur because of inadequate storage and transportation facilities. Many specifications of such facilities are not specified by the manufacturer of the equipment.

In general, three may be many reasons that cause human errors. Some are listed below:

- Low motivation of the staff involved;
- Poor training or skill (competence, qualification) of the concerned staff;
- Improper design of equipment;
- Written instructions for the equipment as well as inadequate maintenance procedures or poor in information;
- Inappropriate workplace environment: poor lighting, high / low temperature, high noise, crowded workspace, etc;
- Inadequate tools and work equipment;
- Complex work tasks;
- Poor organization of work.

4. THE QUANTIFICATION OF THE HUMAN PERFORMANCE RELIABILITY FOR MEASURING THE HUMAN ERROR

Because human operators in mining perform tasks continuously, a general expression of the human performance reliability in order to develop general classic reliability function can be developed in different ways.

Thus, the probability of the human error in the period of time Δt is:

$$P(X_2 / X_1) = z_h(t)\,\Delta t \tag{1}$$

where: X_1 is an event of the human error-free performance at time t; X_2 - an event that indicates that the human error will occur in the time interval [t, $t+\Delta t$]; $z_h(t)$ - the rate or intensity of the human error at time *t, errors/hour*.

The probability of the human error-free performance can be expressed by:

$$P(\overline{X}_2 / X_1)\,P(X_1) = P(X_1) - P(X_2 / X_1)\,P(X_1) \tag{2}$$

which $\overline{X}_2$ is an event according to that the human error will not occur in the interval [t, $t+\Delta t$].

In addition, equation (2) indicates the probability of the human error-free performance on the intervals [0, t] şi [t, $t+\Delta t$].

Equation (2) can be rewritten as:

$$R_h(t+\Delta t) = R_h(t) - R_h(t)\,P(X_1 / X_2) \tag{3}$$

where: $R_h(t)$ represents the reliability of the human performance at time t; $R_h(t+\Delta t)$ - human performance reliability at time $t+\Delta t$.

By inserting equation (1) into equation (3) gives:

$$\frac{R_h(t+\Delta t) - R_h(t)}{\Delta t} = -R_h(t)\,z_h(t) \tag{4}$$

Passing to the limit, equation (4) becomes:

$$\lim_{\Delta t \to 0} \frac{R_h(t+\Delta t) - R_h(t)}{\Delta t} = \frac{dR_h(t)}{dt} = -R_h(t)\,z_h(t) \tag{5}$$

By rearrangement, the equation (5) becomes:

$$-z_h(t)\,dt = \frac{1}{R_h(t)}\,dR_h(t) \tag{6}$$

By integrating considering the time of both members of equation (6) gives, for the period [0, t]:

$$-\int_0^t z_h(t)\,dt = \int_0^t \frac{1}{R_h(t)}\,dR_h(t) \tag{7}$$

Since at $t = 0$, $R_h(t) = 1$, equation (7) becomes:

$$-\int_0^t z_h(t)\,dt = \int_0^{R_h(t)} \frac{1}{R_h(t)}\,dR_h(t) \tag{8}$$

After evaluating the right member of equation (8) gives:

$$\ln R_h(t) = -\int_0^t z_h(t)\,dt \tag{9}$$

Thus, the equation (9) can be written:

$$R_h(t) = e^{-\int_0^t z_h(t)\,dt} \tag{10}$$

Equation (10) is the general function of the human performance reliability. This function can be used to predict the human reliability according to the time *t*, when the time for the human error is described by any of the known statistical distributions.

A study led to getting data for a continuous activity in laboratory conditions. Weibull distributions, and Gama and Log-normal are best suited for analyzing such data. In order to obtain a general expression for the average time to onset of the human error, *MTTHE* (*Mean Time To Human Error*) the equation integrates (10) on the interval [0, ∞]

$$MTTHE = \int_0^\infty R_h(t)\,dt = \int_0^\infty \exp\left[-\int_0^t z_h(t)\,dt\right]dt \quad \text{[hour]} \tag{11}$$

This equation can be used to obtain *MTTHE* when the time errors are governed by any of the known distribution functions.

Literature, which must be recognized that it is poor in highlighting quantitative values for the rate or intensity of the human error, it indicates an average value of $z_h(t) = \lambda_h = 0.08$ *errors/hour* to a specific activity of the mining operators. For an exponential distribution of the time for the human error these can be calculated:

- Human performance reliability, equation (10), for which the duration of 6 hours of a work shift, resulting:

$$R_h(t) = e^{-\int_0^t \lambda_h\,dt} = e^{-\int_0^t 0{,}08\,dt} = e^{-0{,}08\,t} = e^{-0{,}08\times 6} = 0.6187\,;$$

- Average time to onset of the human error, the relation (11):

$$MTTHE = \int_0^\infty e^{-\int_0^t 0,08\,dt} dt = \int_0^\infty e^{-0,08\,t} dt = -\frac{1}{0,08} e^{-0,08t} \Big|_0^\infty = \frac{1}{0,08} = 12.5 \text{ hours.}$$

Under the conditions specified it is expected that the human operator working underground to perform their tasks with a probability of about 60% during a work shift, which is a low value which can be explained by the difficult conditions in which they must carry out their activity. In addition, we should expect to 12,5 hours, i.e. two shifts a human error to appear.

5. CONCLUSIONS

In this paper the theory of the human reliability in activities carried in the coal mining field is applied. After the definition of human reliability and the terms that quantify it qualitatively, respectively the errors and their causes of occurrence there are presented:

- Important factors which affect the performance of human operators;
- The factors which lead to the increasing of the stress for the human operator in mining.

For continuous-time work, as it is done underground, the relations for quantifying the performances of the human reliability and the average time to onset the human error were established.

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