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Performance Shapping Factors in Coal Mining

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Abstract: *Health and Safety Executive statistics, states that 90% of accidents are caused by human error. Coal mining is an industry that has a high risk of work accidents. If the mining process is not in accordance with procedures, the worker's life will be at stake. Most accidents that occur in coal mining are caused by human error, therefore an assessment of the probability of human error or what is called the Human Error Probability (HEP) is very important to do. Human Reliability Analysis (HRA) is part of the risk assessment process which functions to analyze and predict HEP. HRA has been used in many studies to assess the risks involved in large, complex, and dangerous systems. SLIM (Success Likelihood Index Method) is a method used in the HRA field. Prevention and control of human error needs to be done at every stage of work. SLIM can analyze HEP at each stage of the work. SLIM aims to obtain a HEP value. To get the HEP value, we must first find the SLI (Success Likelihood Index) value. Finding the SLI value comes from a weighting questionnaire and PSF (Performance Shapping Factor) assessment that has been filled in by an expert judgment. After the HEP value is obtained, it can be seen which jobs fall into the safe risk level and which the risk cannot be accepted. Furthermore, risk reduction is carried out by making a task analysis of jobs that have a high risk of danger. From the results of the research conducted, it is known what factors cause the error, namely unsafe conditions, unsafe actions, personal factors, and job factors.*

Keywords: *PSF (Performance Shapping Factors), HRA (Human Reliability Analysis), Human Error.*

1. Introduction

The accidents occur in coal mining mostly caused by *human error* so at each stage of work it is necessary to prevent and control the occurrence of *human errors*, therefore a scenario is needed to predict and reduce the occurrence of human errors. SLIM is a scenario that can predict and reduce the occurrence of *human error*. Accidents occurred due to 88% of *unsafe actions* and 10% *unsafe conditions*, both of which could be prevented, and only 2% were *unpreventable* accidents, which were caused by *the act of God* (Heinrich, 1959). From the statistical data on the *Health and Safety Executive*, it can be concluded that 90% of accidents are caused by human error.

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Therefore, the assessment of the probability of human error or what is called the *Human Error Probability* (HEP) is very important to do (Simpson, 1994).

> HRA is part of the *risk assessment process* that functions to analyze and predict HEP (Jung et al, 2001). Currently, there are about 35-40 clearly distinguishable HRA methods. Of the several methods, most of them are methods that are still being considered by HRA experts. The SLIM method and the *Technique for Human Error Rate Prediction* (THERP) are methods that have been approved by five of the six HRA experts who have been trusted since the 1980s (Hollnagel, 1998). When compared with THERP, SLIM is the most flexible method compared to other HRA methods (Kirwan, 1994).

The purpose of this research is to find out what factors influence the occurrence of *human error* in coal mining accidents and to find out how much is the probability of *human error* in an accident in coal mining using the SLIM approach to find out which *task* has the highest probability of *error*, so that these tasks can be given special attention.

2. Theoretical Framework and Hypothesis Development

Performance Shaping Factors (PSF)

PSF or *Performance Influencing Factors* (PIF) are factors that affect the probability (likelihood) of an *error.* At SLIM, these factors are the first step to starting the analysis.One of the steps in the SLIM approach is to assess the weight of each PSF. Table 1 below is an example of *Performance Shaping Factors* (Chiara, 2005).

Table 1.
The Example of*Performance Shaping Factors*

PSF External	
Conditions - Structure - Environment - Work Period - Work *Shift*	*Task* and utensil - Perception - Movement - Compatibility - Prediction
PSF Internal	
- *Training* - Experiences - Skill - Personality	- Intelligence - Motivation - Mental
Stressor	
Mental - *Abruptness*	Psychology - Duration

- Duration - Workspeed - Workload	- Fatigue - Uncomfortable - Hunger, thrist

Success Likelihood Index Method (SLIM)

Namely the techniques used in the HRA field, aiming to analyze the possibility of *human errors* that occur while doing a job. From this analysis, actions can be taken to reduce the possibility of *errors* that occur in a system and can provide improvements in all levels of *safety*.

SLIM is used to measure PSF. This factor relates to the individual, environment or task that has the potential to affect the performance of workers (both positively and negatively). These factors are used to obtain the *Success Likelihood Index* (SLI), which is a form of preference index that is calibrated against existing data to obtain the final HEP result.

The following are the stages in applying the SLIM technique (Embrey, 1994):

a. Predict errors qualitatively
b. Find a suitable PSF
c. Rating each PSF on each task
d. Determine the correct weight
e. Calculate SLI
f. Convert SLI values to HEP values

3. Research Method

Expert judgment is the consideration or opinion of an expert or experienced person. In choosing an *expert judgment*, it should not be arbitrary, therefore the researcher makes several criteria for determining *expert judgment*.

Task analysis is a basic methodology for *human error* assessment and serves to describe and analyze human interactions with the system so as to reduce *human error*. In this study, task analysis functions to determine the tasks (work steps) that exist in coal mining work at PT. X in detail. This *task analysis* itself in this study was used to make a weighting questionnaire. PSF and the PSF assessment questionnaire and

eventually*the error* probability is also calculated in each task and its subtask. In making the *task analysis*, there are various parties involved, starting from the HSE *manager*, related workers, to the *expert judgment*. *The task* analysis in this work was made based on the HSE design procedures, Ergonomics, and *Fatigue* that have been made by PT. X, then developed and made in more detail so that it becomes a *task analysis*. The *task analysis* must also obtain approval from the *expert judgment*.

PSF are the factors that affect the probability of occurrence of *errors*. In this study, the function of the PSF was to make a weighting questionnaire for the PSF and a questionnaire for the PSF assessment. This PSF will also function to calculate SLI. In determining the PSF, the researcher determines it based on existing accident data, from the accident data it can be seen, what are the factors that can cause an error. After determining the PSF, the next stage is to discuss these PSF with *expert judgment*, whether it is true that these PSF are PSF which greatly affect the probability of *errors* in coal mining work or not. The researcher also asked for an opinion from the *expert judgment* whether there might be other PSF that also greatly affect the error probability in coal mining work or not. The PSF weighting questionnaire aims to determine how much influence each PSF has in causing *errors* in coal mining work by giving weight to each PSF in each task. This questionnaire is based on a late *task analysis*. This questionnaire is given to *judges* who have met the criteria as *expert judgment*. On condition, the *judges* are not allowed to fill out the questionnaire simultaneously with other judges. This is avoided so that the *judges* do not discuss the values given to the questionnaire, this is also avoided so that the *judges* do not imitate the values given by other *judges*. Another requirement and is the main point is that they are willing to spend their time in working hours and get permission to carry out this assessment, and to be asked for information related to coal mining work.

In giving weight, there are scales ranging from a scale of 1 to a scale of 10, 10 has the greatest influence and 1 has the smallest effect. This means, the greater the number given, the more influential the PSF will be in the occurrence of errors in coal mining work at PT. X. Inversely proportional, the smaller the number given, the PSF

does not really have an effect on the occurrence of errors in coal mining work at PT. X is compared to other PSF. This questionnaire is based on a late *task analysis*. This questionnaire is given to *judges* who have met the criteria as *expert judgment*. One of the steps in the SLIM approach is to assess the weight of each PSF. The determination of this weight aims to determine how much influence each PSF has in causing *errors* in coal mining work. In addition, weight determination is also used to calculate SLI. In determining the weight, the first step is that the weight of the PSF is determined through the results of the PSF weighting questionnaire that has been filled in by the expert judgment. From the questionnaires that have been obtained, the results of filling in the weights of the judges are averaged. The weight is then normalized (each value is divided by the total score). The total normalized weight must be 1.00.

4. Results and Discussion

The *judges* consist of people from various professions who have a lot of knowledge about coal mining work at PT. X. *Expert judgment* consists of *supervisor, technician / mechanic, driver / operator*, and Head of HSE. The main point of *judges* is that they try to make an assessment and they are also willing to spend time during working hours to be asked for information related to coal mining work, because this assessment requires a lot of time.

Table 2 is the result of discussion with the expert judgment.

Table 2.
PSF which has been agreed upon by the *Judges*

No.	PSF
1	*Unsafe Condition*
2	*Unsafe Action*
3	*Personal Factor*
4	*Job Factor*

From the results of discussions with the *judges*, it was found that there were 4 PSFs that affected the probability of an *error.*

The results of the weighting questionnaire can be seen in Table 3.

Table 3.
Weighted Questionnaire Results

PSF	Normalized Weights
Unsafe Condition	0,36
Unsafe Action	0,35
Personal Factor	0,2
Job Factor	0,09

From this table, it can be seen that in coal mining work, *unsafe conditions* have the greatest influence in causing *errors*. Followed by the *unsafe action*, workers who take *unsafe actions* are more likely to have an accident than workers who behave safely. Then *personal factors,* such as mental / psychological disability, lack of knowledge and skills, physical stress, and inappropriate motivation can also influence the rate of accidents. The next factor is work factors, such as lack of supervision, inadequate design, and inadequate tools / equipment / materials which also affect the occurrence of errors. There have been many cases of accidents that have occurred due to these factors. These four factors are the factors that most influence the coal mining work at PT. X.

5. Conclusion, Implication and Limitation

5.1. Conclusion

Factors that affect the occurrence of *errors* in coal mining work at PT. X is the *unsafe condition, unsafe action, personal factor, and job factor*.

5.2. Implication and Limitation

Recommendations for reducing probability *human error* that occurred in coal mining work at PT. X is as follows:

a. The task in the SOP should be more detailed
b. Provide SOP socialization to workers
c. Increased supervision of workers' work methods
d. Set the rest time for workers

e. The holding of routine training
f. Refresh is associated with the task
g. Employee competency *assessment*

In selecting an *expert judgment, Judges* who meet all predetermined criteria must really be selected, and the most important thing is, they are willing to spend time during working hours to be asked for information related to grinding work. For further research, it is hoped that the task analysis will be made in more detail and the tasks that will calculate the probability of *error* are more.

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