Development of Human Error Identification Tool for Processing Industries

By

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Dissertation submitted in partial fulfillment of

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CERTIFICATION OF APPROVAL

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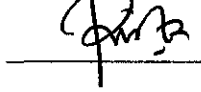
Approved by,



(Dr. Risza Rusli)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

MAY 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

ABDUL SHAFIQ B. HASSAN

ABSTRACT

Human error analysis method quantitatively is to be investigated by development of tool for analyzing human error in processing industries and oil and gas industries. The development of quantitative human error analysis is for the improvement of human performance focusing critical industrial location such as plant site and offshore. The development of the tools is based on traditional analyzing method that has been developed in the past such as Swiss Cheese and Human Reliability Assessment. This project aims to develop a tool that will assess and identified human error by quantification method for studies and enhancement of human performance in processing industries. The development of human error identification tools is still new in chemical industries and tool that works based on quantitative methods is still not much due to lack of data. In this project, there are two case studies used. First is from a report on Data Informed Model of Performance shaping Factors for use in Human Reliability Analysis, which is for calculation of error probabilities. Second is to calculate risk level which is from case study of method use for food processing industry in Japan. The result of this project is a simple, easy and practicable tool for workers in plant to assist them to evaluate human error probabilities and risk level due to standardized factor of error in plant.

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LIST OF ABBREVIATION

FTA : Fault Tree Analysis

HRA : Human Reliability Assessment

PRA : Probability Risk Assessment

SPAR-H : Standardized Plant Analysis Risk – Human Reliabilty Assessment

HEP : Human Error Probabilities

PSF : Perfomance Shaping Factor

HMI : Human Machine Interface

VB : Visual Basic 2008

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CHAPTER 1 INTRODUCTION

1.1 Background of study

Human error is one of the aspects in the study of human factors. In recent years, the development, analysis and intervention methods are based on research and studies, rather than the computational knowledge. There is slight doubt that human errors are one of the factors contributing to the majority of safety incidents and accidents which occur within complex systems. Accidents such as that at Chernobyl had shown that the need for consideration of human error in high-risk systems. Such accidents have improved research and development in human contributory factor analysis. Human error identification is critical to assessing risk. Human error contribution to risk is assessed through the use of human error analysis tools. The role of tools extends in many industries, including healthcare, aviation and railways wherever human errors occur within systems. Prevention and/or reduction in the number of accidents and incidents require a reduction in human error in the system. Human error and accident management involves the prevention of human errors, the recovery from errors, and the containment of the consequences that result from error occurrence (Cacciabue, et al., 2005). The first step in this process is error identification. Identifying the errors that frequently result in the occurrence of incidents and accidents may allow the development of appropriate prevention and/or mitigation strategies.

A variety of human error identification tools have been developed to aid error identification and classification, involving at least one error taxonomy and some including human error quantification. For instance, The Swiss Cheese model is used in the risk analysis and risk management of human systems while The Domino Effect is a model of chain reaction that occurs when a small change causes a similar change nearby, and so on in linear sequence. Fault Tree Analysis (FTA) is a top down, deductive failure analysis using Boolean logic to combine a series of lower-level events. Other tools which are quite similar to FTA are Event Tree Analysis. Besides, risk assessment model such as Probability Risk Assessment (PRA) and Human Risk Assessment (HRA) are a widely used to evaluate risks associated with a

complex engineered technological entity (such as an airliner or a nuclear power plant. These tools have been used to develop new tools for error and risk analysis/identification especially in nuclear, aviation and construction industries.

However, the application of systematic methods in human error identification is still early in chemicals industry. Tools are being developed and data and statistics are being gathered. Validation of the basic foundation of human error has been developed over the last 60 years, illustrates reliability and growth on a moderately concrete establishment of knowledge. Philosophies about human performance in industries have been distinguished to a point where major contributions to an error may be recorded, giving recent safety systems designer and analyst valuable structures and techniques.

1.2 Problem Statement

Human errors refer to the environmental, organizational and occupation aspect as well as human and individual traits which manipulate the behavior at work in a means which can have an effect on an organization's wellbeing and safety performance. A straightforward method to observe human error is to consider about three aspects: the work, the person and the organization and how they interrelate to impact on health and safety associated with human behavior. Subsequent to an industrial accident relating individual failure, using human error identification tools can identify the causes and contributing human error factors. Establishing these underlying causes of an accident/incident is the key to preventing similar human error accidents/incidents.

The quantification of human reliability is based on having statistically relevant data of human tasks and the associated error rates. Any similar study could refer to the databases and call off the required values and have data that was reasonably fit for purpose. The basic problem with quantitative methods is a lack of data to form the foundation for the assignment of human probabilities to individual task elements. Given that underlying databases are incomplete, experts are asked to provide data that the databases cannot provide (Nagy, et al., 2002). This then, leads to a combination of subject matter expert opinion and quantitative analysis supplementing each other, which is open to criticism, argument and may not even be repeatable without careful recording of the expert's demographics. Conventional

human reliability analyses are useful in the case of routine highly skilled activities, in the sense that humans may be said to behave very much like (Nagy, et al., 2002). There is not the need for deep thought, consideration and interpretation of the operating environment. Simple human error analysis methods can certainly be adequate. Increasing complexity of the environment and the human task however, does need a more demanding assessment technique with subsequent validation.

Human error identification techniques are numerous, and there are many papers on each technique. As recorded by Wiegmann, Rich and Shappell (2000), Kirwan (, et al., 1998) describes thirty-eight approaches for error identification. They are categorized by type of approach and are critiqued using a range of assessment criteria. The development of human error identification tools for studies and improvement of human performance are still new in chemical industries. However, error analysis tools such as Fault Tree, Event Tree, The Swiss Cheese model and Domino effect has been used widely to evaluate error and risk reliability in industries. These tools works based on probability method which is related to the frequency of event to happen depending on three aspects of observing human error: the work, the person and the organization. Nevertheless, based on these traditional methods, a new human error analysis tools may well be developed for measuring human error that contributed to human performance analysis in industries.

1.3 Objectives

The main purpose of this project is to develop a tool that will evaluate and identified human error by quantification method for analysis and improvement of human performance in chemical industries.

- The tool that will be developed is a user-friendly which means is simple, accessible for user, with easy operating procedures particularly for workers (operators and technicians) that are present during the operational process in the chemical industries.
- This tool is design to help and assist chemical industries in reducing and more importantly preventing accidents/incidents to happen during production operation take place.
- This tool act as an indicator to personnel in plant of which to specify which process produce higher risk of accidents/incidents to happened, what are the

error that should be avoided during the procedures and how to prevent small accident which may contributed to bigger problems if wrong measurement is taken.

1.4 Scope of study

Human error analysis by quantitative means need to be develop by researches and studies on well established tools that has been developed earlier. Most of the tools are developed based on probability calculation of the certain circumstances such as types of accident, root cause of accidents and the like hood of accidents to happen. The probabilities for each condition to happen are to be quantified numerically and the likenesses of each case to happen are calculated. The study of past conventional method such as Swiss Cheese Model, Domino Effect Theory, Fault Tree and Event Tree Analysis, Probability Risk Assessment (PRA) and Human Risk Assessment (HRA) are important in developing the new tool as these past method is a reference to build up a new systematic method.

The study of error identification is also important, for instance, types of accident, root cause of accidents and the like hood of accidents to happen in order to know the frequency of events to happen and eventually will lead to the end result. The software that has been identified in order to develop human error analysis tool, is using Microsoft Excel along with Microsoft Visual Basic 2008. Microsoft Excel is a computer application used to create and managed spreadsheets. Microsoft Visual Basic 2008 is used to design the program in which consists of two main steps. First, is to design the program form, which will be the interface between the user and the program. Second, is to include the coding in order to create the program that will calculate error probability and risk level according to factors affecting human error.

1.5 Relevancy of the Project

Human error identification tool in oil and gas and chemical industries is important as there are fewer tools developed for processing industries unlike in nuclear power and aviation industries. This tool is to help and assist chemical industries in reducing and more importantly preventing accidents/incidents. The tools are easy, simple and practicable to use in plant.

1.6 Feasibility of Study

For this project, the first semester will cover the literature review for the past conventional method and data gathering of types of accident, root cause of accidents and the like hood of accidents to happen. This semester also will cover the formulation of methodology that will be used in developing the tool by using software that has been identified. Software chosen are simple to use and easy to understand to help the development of the tool.

The second semester will cover the development of tool using the software which is using Microsoft Excel along with Microsoft Visual Basic 2008. The software is easy to get/downloaded and installed.

CHAPTER 2 LITERATURE REVIEW

Numerous references to human error are connected with high-profile catastrophic accident/incident. Nuclear power plant accidents, oil rig fires and chemical plant disasters are the evidence to the public and their research towards human error analysis. Human error identification tool is developed based from the past conventional method used in evaluating human error. Some of the methods are:

Swiss Cheese Model

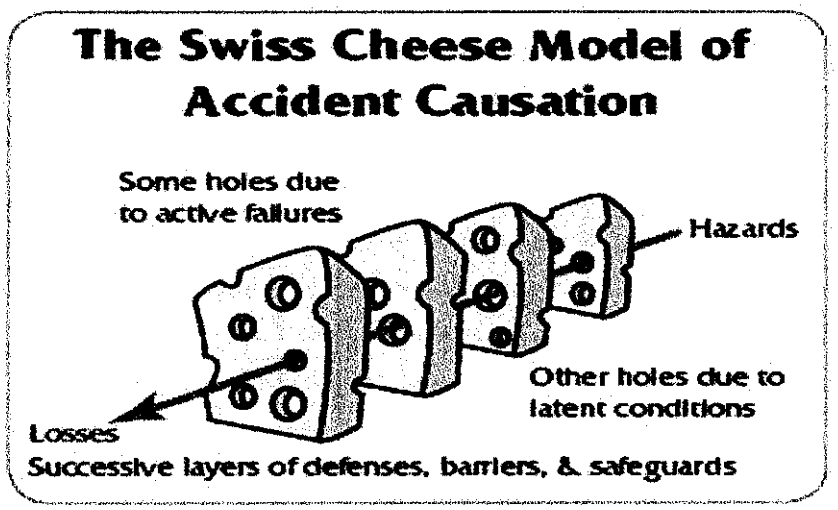


Figure 1: The Swiss Cheese Model of Accident Causation (Reason et. 1990)

This model combines the earlier ideas of both errors and the systems in which humans work, into a complete "Swiss Cheese" model through which errors are acceptable to occur, in the book, Human Error (Reason et al., 1990). James Reason characterizes the "trajectory of accident opportunity" with "Swiss cheese" form of accident causation (Reason et al., 1990). It separates the operation of unsafe acts from emotional factors and organizational barrier. The "Swiss-cheese model" is a generally adopted model in human factors for explaining accident causation. The Swiss cheese model hypothesizes is that in any system there are many levels of defense. Each of these levels of defense has little 'holes' (known as 'latent conditions') in it which are caused by poor design, decision-making, procedures, lack

of training, limited resources, etc. If conditions become aligned over consecutive levels of defense, it creates an opportunity for incident to occur. When a combination of factors and errors break all levels of defenses, a safety incident occurs." (Carthey & Clarke, 2010, p.6). From the Swiss Cheese, accidents occur because weaknesses or 'windows of opportunity' exist or, else, open up at all levels in the system, allowing a 'chain of events' to start at the upper level of the structure and move down, ultimately resulting in an accident if it is not stopped before such thing occurs. In other words, most accidents can be traced back to weaknesses at all levels in the system. *(Perezgonzalez et al, 2011.)*.

2.2 Probabilistic Risk Assessment and Human Reliability Analysis

Probabilistic risk assessment (PRA) uses probability distributions to differentiate inconsistency or uncertainty in risk estimation. The quantitative analysis of uncertainty and variability can provide a more complete characterization of risk than is possible in the point estimate approach. Risk management decisions are often based on an evaluation of high end risk to an individual, for deterministic analyses, this is generally developed by the combination of a mix of central tendency and high-end point values for various exposure parameters). In a PRA, risk is characterized by two quantities:

1. The magnitude (severity) of the possible adverse consequence(s), and
2. The likelihood (probability) of occurrence of each consequence.

Consequences are expressed numerically (e.g., the number of people potentially hurt or killed) and their likelihoods of occurrence are expressed as probabilities or frequencies (i.e., the number of occurrences or the probability of occurrence per unit time). The total risk is the expected loss: the sum of the products of the consequences multiplied by their probabilities. It would be of concern if rare but high consequence events were found to dominate the overall risk, particularly as these risk assessments are very sensitive to assumptions.

The practice of Human Reliability Analysis goes back to the early 1960s, but the majority of HRA methods were developed in the middle of the 1980s mainly as a

consequence of the concern caused by the accident in 1979 at the nuclear power plant at Three Mile Island. The traditional approach is first to determine the Human Error Probability (HEP) either by using established tables, human reliability models, or expert judgment. One of the methods of HRA is the SPAR-H (Standardized Plant Analysis Risk-Human Reliability Analysis) method which was developed to estimate HEPs for use in the SPAR H models used in commercial nuclear power plants. SPAR-H is used as part of PRA in over 70 US nuclear power plants. The formula of HEP calculation by using this method is given as:

$$HEP = (1e\text{-}2x\ PSFcomp.)/(1e\text{-}2x(PSFcomp.\text{-}1)+1)$$

Second step is to account for the influence of possible Performance Shaping Factors (PSF) such as task characteristics, aspects of the physical environment, work time characteristics, etc. In the SPAR-H (Standardized Plant Analysis Risk-Human Reliability Analysis) method, there are eight PSF used to calculate HEP *(Boring and Blackman 2007)*.. This influence is expressed as a numerical factor that is used to modify the basic HEP. HRA methods in practice turned out not to be sufficiently effective and the need for substantial improvements was gradually realized. In 1990, this was expressed as a criticism against HRA on the following points (Dougherty, 1990):

- Existing empirical data are insufficient to support quantitative predictions of human performance in complex systems.
- Expert judgments can be used *in lieu* of empirical data, but there is a lack of agreement in the use of expert judgment methods.
- Data from simulator studies can be used instead of empirical data, but the calibration to real life situations is inadequate.
- The accuracy of predictions from HRA methods is debatable and generally unproved, particularly for non-routine tasks.
- The psychological realism in most HRA methods is inadequate.
- The treatment of important Performance Shaping Factors is inadequate.

Considering the historical basis for HRA methods, it is reasonable to suggest that one improvement should be a better integration of psychological theory with HRA models and methods.

2.3 Performance Shaping Factor

Whether the task type is determined to be diagnosis, action, or some combination of the two, this section presents in order corresponding to the SPAR-H worksheets, general definitions for the PSFs that constitute part of the analysis process. The following PSF multiplier level assignments are applied to the nominal HEP as appropriate for computing HEP. The derivation of the SPAR-H PSF multipliers is documented in (Boring and Blackman, 2007).

1. <u>Available Time</u> Available time refers to the amount of time that an operator or a crew has to diagnose and act upon an abnormal event. A shortage of time can affect the operator's ability to think clearly and consider alternatives. It may also affect the operator's ability to perform. Definitions differ somewhat, depending on whether the activity is a diagnosis activity or an action. The diagnosis values are provided below:
Inadequate time - if the operator cannot diagnose the problem in the amount of time available, no matter what s/he does, then failure is certain. (Probability of failure = 1) ***Barely adequate time*** - 2/3 the average time required to diagnose the problem is available. (Multiplier = 10) ***Nominal time*** - on average, there is sufficient time to diagnose the problem.(Multiplier = 1) ***Extra time*** - time available is between one to two times greater than the nominal time required, and is also greater than 30 minutes. (Multiplier = 0.1) ***Expansive time*** - time available is greater than two times the nominal time required and is also greater than a minimum time of 30 minutes; there is an inordinate amount of time (a day or more) to diagnose the problem. (Multiplier = 0.01)

2. Stress and Stressors

Stress can include mental stress, excessive workload, or physical stress (such as that imposed by difficult environmental factors). It includes aspects of narrowed attention field or muscular tension, and can include general apprehension or nervousness associated with the importance of an event. Environmental factors often referred to as stressors, can induce stress in a person and affect the operator's mental or physical performance. The assignment and definition of levels of stress or stressors is identical across action and diagnosis and action tasks:

Extreme - a level of disruptive stress in which the performance of most people will deteriorate drastically. This is likely to occur when the onset of the stressor is sudden and the stressing situation persists for long periods. (e.g., catastrophic failures can result in extreme stress for operating personnel because of the potential for radioactive release). (Multiplier = 5)

High - a level of stress higher than the nominal level (e.g., multiple instruments and enunciators alarm unexpectedly and at the same time; loud, continuous noise impacts ability to focus attention on the task; the consequences of the task represent a threat to plant safety). (Multiplier = 2)

Nominal - the level of stress that is conducive to good performance. (Multiplier = 1)

3. Complexity

Complexity refers to how difficult the task is to perform in the given context. Complexity considers both the task and the environment in which it is to be performed. The more difficult the task is to perform, the greater the chance for human error. Complexity also considers the mental effort and physical efforts required. A task with greater complexity requires greater skill and comprehension to complete successfully. Multiple variables are usually involved in complex tasks. The multipliers are:

Highly complex - Very difficult to perform, there is much ambiguity in what needs to be diagnosed or executed. Many variables are involved, with concurrent diagnoses or actions (i.e., unfamiliar maintenance task requiring high skill). (Multiplier = 5)

Moderately complex – somewhat difficult to perform, there is some ambiguity in what needs to be diagnosed or executed. Several variables are involved, perhaps with some concurrent diagnoses or actions (i.e., evolution performed periodically with many steps). (Multiplier = 2)

Nominal - not difficult to perform, there is little ambiguity in the diagnoses or actions. Single or few variables are involved. (Multiplier = 1)

Obvious diagnosis - diagnosis become greatly simplified. There are times when a problem becomes so obvious that it would be difficult for an operator to misdiagnose it. (There is no *obvious action PSF* level counterpart. Easy to perform actions are encompassed in the nominal complexity rate.) (Multiplier = 0.1)

4. Experience and Training

This PSF refers to the experience and training of the operator(s) involved in the task. Included in this consideration are years of experience of the individual or crew, and whether or not the operator/crew has been trained on the type of accident, the amount of time passed since training, and the systems involved in the task and scenario. Specific examples where training might be deficient are guidance for monitoring plant operation during apparently normal, stable conditions for the purpose of promoting the early detection of abnormalities. The multipliers are as follows:

Low - less than six months experience and/or training. This level does not provide the level of knowledge and deep understanding required to adequately perform the required tasks and does not expose individuals to various abnormal conditions (Multiplier = 10)

Nominal - more than six months experience and/or training. This level of experience/training provides an adequate amount of normal schooling and instruction to ensure that individuals are proficient and exposed to abnormal conditions. (Multiplier = 1)

High - extensive experience. This level of experience/training provides operators with extensive knowledge and practice in a wide range of potential scenarios. (Multiplier = 0.1)

5. Procedures

This refers to the existence and use of formal operating procedures for the tasks under consideration. Common problems seen in event investigations for procedures include situations where procedures give wrong or inadequate information regarding a particular control sequence. Another common problem is the ambiguity of steps. The multipliers are as follows:

Not available - the procedure needed for a particular task is not available. (Multiplier = 50)

Incomplete - information needed is not contained in the procedure (Multiplier = 20)

Available, but poor - a procedure is available but it is difficult to use because of ambiguity, or lack in consistency that it impedes performance. (Multiplier = 5)

Nominal - procedures are available and enhance performance. (Multiplier = 1)

Diagnostic/symptom oriented - diagnostic procedures assist the operator/crew in correctly diagnosing the event. Symptom-oriented procedures provide the means to maintain critical safety functions. These procedures allow operators to maintain the plant in a safe condition, without the need to diagnose the event (Multiplier = 0.5; diagnosis only)

6. Ergonomics and HMI

Ergonomics refers to the equipment, displays and controls, layout, quality, and quantity of information available from instrumentation, and the interaction of the operator/crew with the equipment to carry out tasks. The adequacy or inadequacy of computer software is also included in this PSF. The PSF levels are:

Missing/Misleading - the required instrumentation fails to support diagnosis or post diagnosis behavior, or the instrumentation is inaccurate (Multiplier = 50)

Poor - the design of the plant negatively impacts task performance (e.g., poor labeling, , or poor computer interfaces).(Multiplier =20)

Nominal - the design of plant supports correct performance, but don't enhance performance (e.g. operators provided useful labels; the computer interface is plenty.(Multiplier = 1)

Good - the design of the plant positively impacts performance, providing needed information and ability to carry out tasks in a way that lessens error. (Multiplier = 0.5)

7. Fitness For Duty

Fitness for duty refers to whether or not the individual performing the task is physically and mentally fit to perform the task at the required time. Fitness for duty includes factors associated with individuals, but not related to training, experience, or stress. The levels are:

Unfit - the individual is unable to carry out the required tasks, due to illness or other physical or mental incapacitation. (Probability of failure = 1)

Degraded fitness - the individual is able to carry out the tasks, although performance is negatively affected. Mental and physical performance can be affected if an individual is ill, overconfident in their abilities to perform, experiencing fatigue from long duty hours, taking cold medicine or being distracted by personal matters. (Multiplier = 5)

Nominal - individual able to carry out tasks; there is no known performance degradation(Multiplier = 1)

8. Work Processes

Refers to work including inter-organizational, safety culture, work planning, communication, and management support and policies. How work is planned, communicated, and executed can affect individual and crew performance. Work processes include consideration of coordination, command, and control. Work processes also include any management, organizational, or supervisory factors that may affect performance The multipliers used in Work Processes include:

Poor - performance is negatively affected by the work processes at the plant (e.g., shift turnover about ongoing maintenance activities; poor command and control by supervisor(s); performance expectations are not made clear). (Multiplier = 2)

Nominal - performance is not significantly affected by work processes at the plant, or work processes do not appear to play an important role (e.g., crew performance is adequate; information is available. (Multiplier = 1)

Good - work processes employed at the plant enhance performance and lead to a more successful (e.g., good communication; well-understood and supportive policies;cohesive crew). (Multiplier = 0.8)

2.4 Numerical Scoring Method incorporating PSF

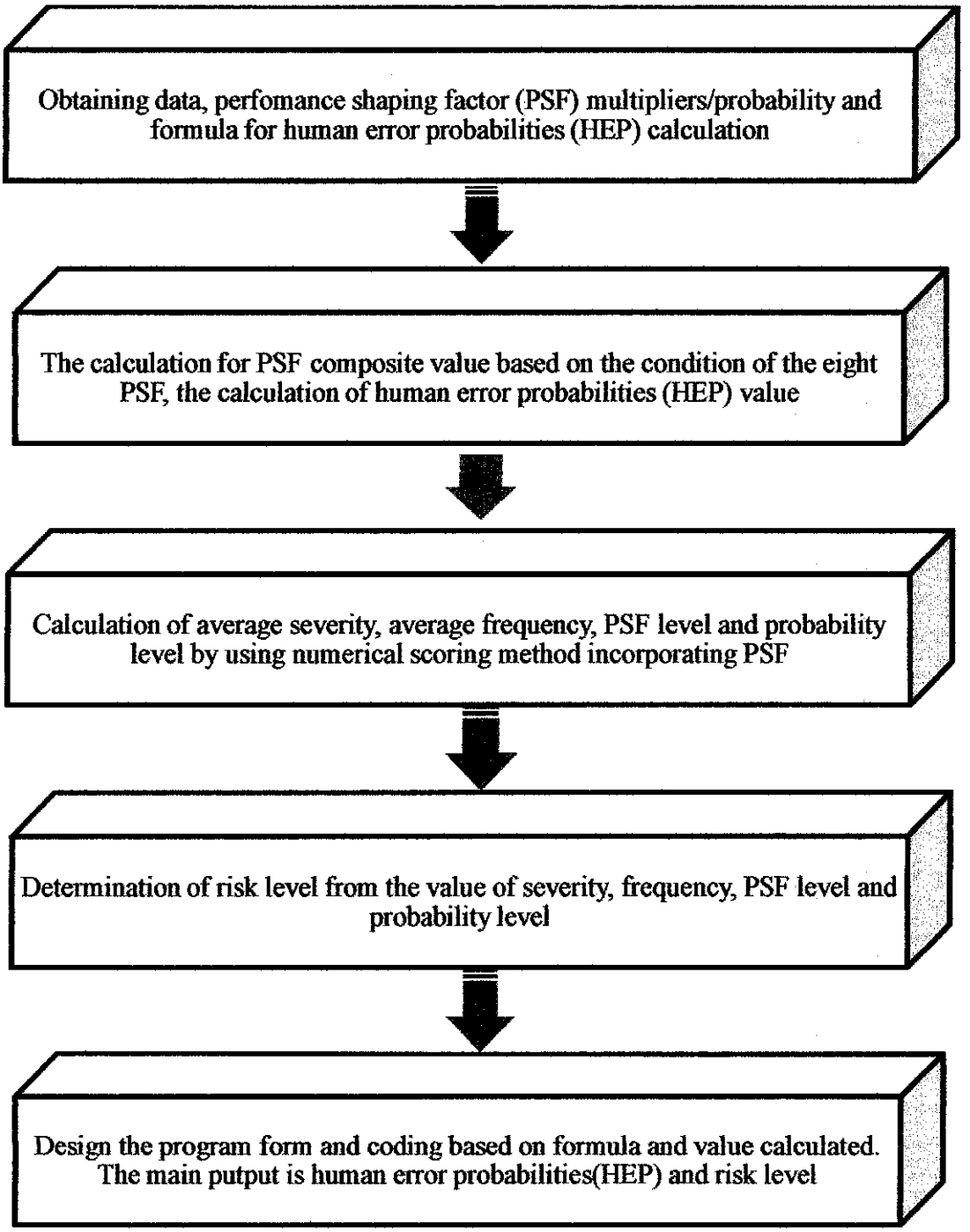
The numerical scoring method is considered an addition or multiplication method; severity, probabilities and frequency are added or multiplied to calculate risk indexes and to determine the level of risk. PSFs can be included in the computation. In the risk estimation, C and P = f are determined as described earlier, an excision is performed, and the PSF is determined. When the sum of the score is less than or equal to four, the human error index is one; when the sum is less than or equal to seven, the human error index is two; for all other scores, the human error index is four (T. Moriyama, H. Ohtani *Risk Assessment Tool Incorporating Human error Probabilities in Japanese small size establishment / Safety Science 47 2009)*.. As in the traditional risk assessment, the value can vary depending upon the type of hazardous situation. This method of risk assessment is used in the food processing industry in Japan.

2.5 Tool Development using software: Visual Basic 2008 and Microsoft Excel

Microsoft Visual Basic for 2008 is an implementation of Microsoft's event-driven programming language. Microsoft Visual Studio is an integrated development environment (IDE) from Microsoft. It is used to develop console and graphical user interface applications along with Windows Forms applications, web sites, web applications, and web services in both native code together with managed code for all platforms supported by Microsoft Windows. VB enables building user defined functions, automating processes and accessing Windows API and other low-level functionality through dynamic-link libraries (DLLs It supersedes and expands on the abilities of earlier application-specific macro programming languages such as Word's WordBasic. It can be used to control many aspects of the host application, including manipulating user interface features, such as menus and toolbars, and working with custom user forms or dialog boxes. VB can also be used to create import and export filters for various file formats, such as Open Document (ODF). As its name suggests, VB is closely related to Visual Basic and uses the Visual Basic Runtime Library.

CHAPTER 3 METHODOLOGY

3.1 Research Methodology



3.2 Data Gathering

3.2.1 Performance Shaping Factor (PSF) determination and Calculation of HEP

1. The first step in human error identification is obtaining data, performance shaping factor (PSF) multipliers/probability, and formula for human error probability (HEP) calculation. These data can be obtained through questionnaire survey and research such as thesis and journal from the internet.

2. Each of the PSF's (from the SPAR H method) each has 3 to 5 condition with different value of multipliers/probability.

Available Time		
Stress/Stressors		
Complexity		
Experience Training		
Procedures		
Ergonomics/HMI		
Fitness For Duty		
Work Processes		

Table 1: PSF Analysis Data

The calculation of PSF_{comp} is the multiplication of the multiplier for each condition of the factors. The values for the eight conditions of factors are multiply together.

3. The calculation of Human Error Probability by using Performance Shaping Factor (PSF) is as followed:

$$HEP=(1e\text{-}2x\ PSFcomp.)/(1e\text{-}2x(PSFcomp.\text{-}1)+1)$$

3.2.2 Risk Level Determination

1. To determine the risk level by numerical scoring method, the formula given is

   Severity (S) x Probability (P) x Frequency (F) x PSF (H) = Risk Level

2. The calculations of all the circumstance are based on PSF values. The average value for all the eight PSF condition are as follow:

Average Severity = (S1+S2+S3+S4+S5+S6+S7+S8)/8

Average Frequency = (F1+F2+F3+F4+F5+F6+F7+F8)/8

PSF Level = (H1+H2+H3+H4+H5+H6+H7+H8)/8

Probability: $0.99 \geq p \geq 1$ P=6

$0.5 \geq p > 0.99$ P=4

$0.01 \geq p > 0.5$ P=2

$0.000001 \geq p > 0.01$ P=1

Severity of harm (S)	value
catastrophic	10
serious	6
moderate	3
minor	1

Probability (P)	value
very likely	5
likely	4
unlikely	2
remote	1

Frequency (F)	value
frequent	4
probable	3
occasional	2
remote	1

PSF (H)	value
significant	4
exist	2
in-significant	1

risk level	score (R)	
	addition	multiplication
IV	23 to 24	145 to 960
III	13 to 22	70 to 480
II	7 to 12	25 to 69
I	less than 6	less than 24

addition	Risk (R) (S) + (P) + (F) + (H)
multiplication	Risk (R) (S) x (P) x (F) x (H)

Table 2 : Numerical scoring method using PSF

3.3 Tool Development

1. Visual Basic

Visual Basic was designed to be easily learned and used by beginner programmers. The language not only allows programmers to create simple GUI applications, but to also develop complex applications. Programming in VB is a combination of visually arranging components or controls on a form, specifying attributes and actions of those components, and writing additional lines of code for more functionality. Since default attributes and actions are defined for the components, a simple program can be created without the programmer having to write many lines of code. Performance problems were experienced by earlier versions, but with faster computers and native code compilation this has become less of an issue.

Forms are created using drag-and-drop techniques. A tool is used to place controls (e.g., text boxes, buttons, etc.) on the form (window). Controls have attributes and event handlers associated with them. Default values are provided when the control is created, but may be changed by the programmer. Many attribute values can be modified during run time based on user actions or changes in the environment, providing a dynamic application. By inserting code into the event handler for a key press in a text box, the program can automatically translate the case of the text being entered, or even prevent certain characters from being inserted.

2 Microsoft Excel

Microsoft Excel is a commercial spreadsheet application written and distributed by Microsoft . It features calculation, graphing tools, pivot tables, and a macro programming language called Visual Basic for Applications. It has been a very widely applied spreadsheet for these platforms. For this project, Microsoft Excel is been used for data grouping, tables, data collection, calculation and execution of the correct function in order to get the end value/result.

CHAPTER 4 RESULT AND DISCUSSION

1. Calculation of Human Probability Factor, techniques used is:

   - Performance Shaping Factor (PSF),
   - Human Error Probability (HEP)
     - Nominal human error probability;
     - Basic human error probability;

Condition	Multiplier	Condition	Multiplier	Condition	Multiplier	Condition	Multiplier
Inadequate	P=1	Extreme	5	Highly	5	Low	10
Barely Adequate	10	High	2	Moderately	2	Nominal	1
Nominal	1	Nominal	1	Nominal	1	High	0.5
Extra	0.1			Obvious diagnosis	0.1		
Expansive	0.01						

Condition	Multiplier	Condition	Multiplier	Condition	Multiplier	Condition	Multiplier
N/A	50	Misleading	50	Unfit	P=1	Poor	2
Incomplete	20	Poor	10	Degraded Fitness	5	Nominal	1
Available but Poor	5	Nominal	5	Nominal	1	Good	0.8
Nominal	1	Good	1				
Diagnostic	0.5						

Table 3: Performance Shaping Factor Analysis Result

- This section presents in general definitions for the PSFs that constitute part of the analysis process. Note that when an analyst encounters a PSF for which there is inadequate information, the nominal assignment is assumed. The following PSF multiplier level assignments are applied to the nominal HEP as appropriate for computing HEPs.

A	Range of available time		S		
	Inadequate	P=1	10	4	4
	Barely Adequate	10	10	4	4
	Nominal	1	3	2	2
	Extra	0.1	1	1	1
	Expansive	0.01	1	1	1
B	Stress/Stressors Level				
	Extreme	5	6	3	2
	High	2	6	3	2
	Nominal	1	3	2	2
C	Complexity of the task/job/work				
	Highly	5	6	3	2
	Moderately	2	6	3	2
	Nominal	1	3	2	2
	Obvious diagnosis	0.1	1	1	1
D	Experience and Training				
	Low	10	10	4	4
	Nominal	1	3	2	2
	High	0.5	1	1	1
E	Working Procedures				
	N/A	50	10	4	4
	Incomplete	20	10	4	4
	Available but Poor	5	6	3	2
	Nominal	1	3	2	2
	Diagnostic	0.5	1	1	1
F	Ergonomics/HMI				
	Misleading	50	10	4	4
	Poor	10	10	4	4
	Nominal	5	6	3	2
	Good	1	3	2	2
G	Individual Fitness for Duty				
	Unfit	P=1	10	4	4
	Degraded Fitness	5	6	3	2
	Nominal	1	3	2	2
H	Work/Job/Tasks Processes				

	Poor	2	6	3	2
	Nominal	1	3	2	2
	Good	0.8	1	1	1

Table 4: PSF, Severity, Frequency, and PSF Level Data

M = Multipliers/Probability S = Severity

F = Frequency H = PSF

3 By using Visual Basic, the design of the program is as the form below. From the Excel format of the data, the data is been display in the form of questionnaire where the user need to choose certain condition there are facing due to the performance factor. The button command is used so that is it easier for end - user to choose and get the result which is the error probability.

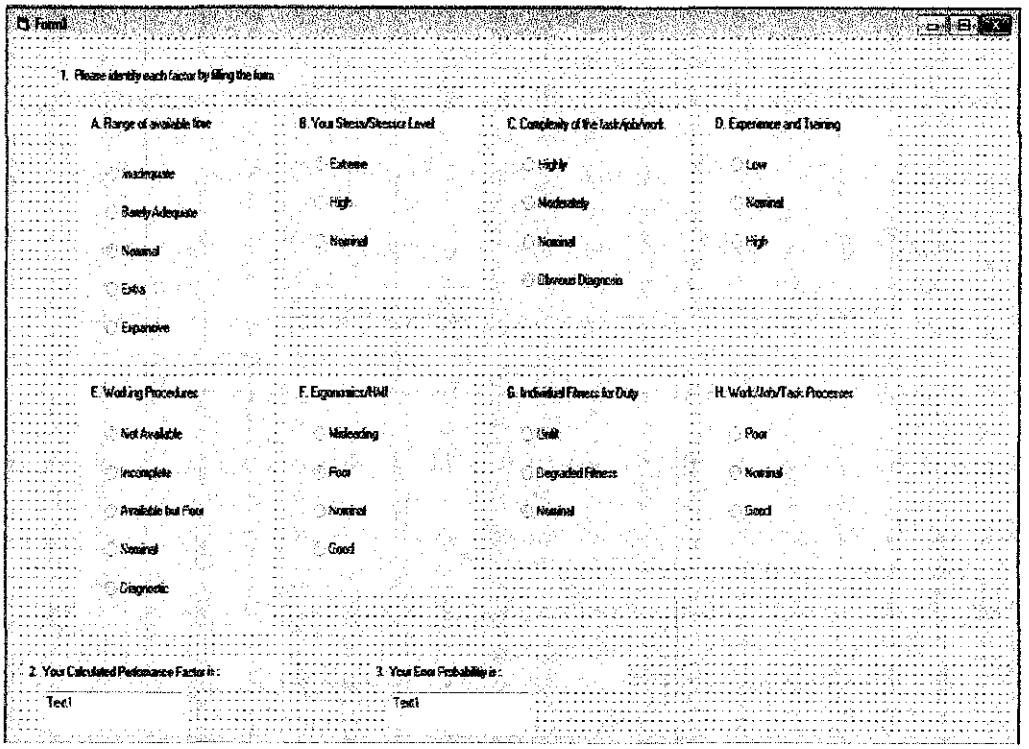


Figure 3: Visual Basic design form

4 The coding for the program is to be call for the program to function according to what has been decided earlier in the methodology. The progress for the coding part for the program is still at early stage where some need to be revised and change to suit the program. View ***Appendix 1*** for complete coding.

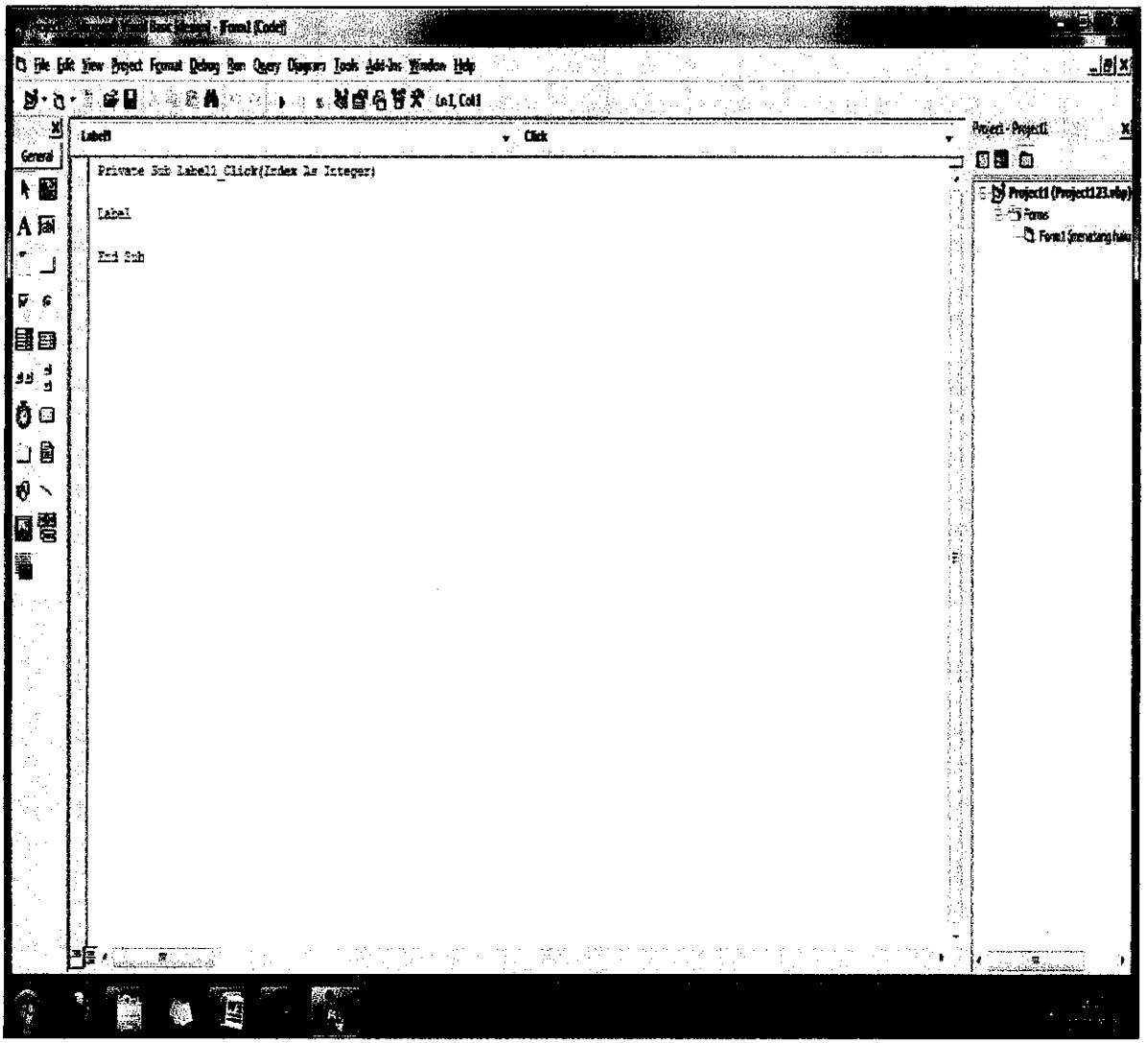


Figure 4: Visual Basic coding form

5 The completed design form and coding for the tool are tested and run in Microsoft Visual Basic 2008 and below is the example of program

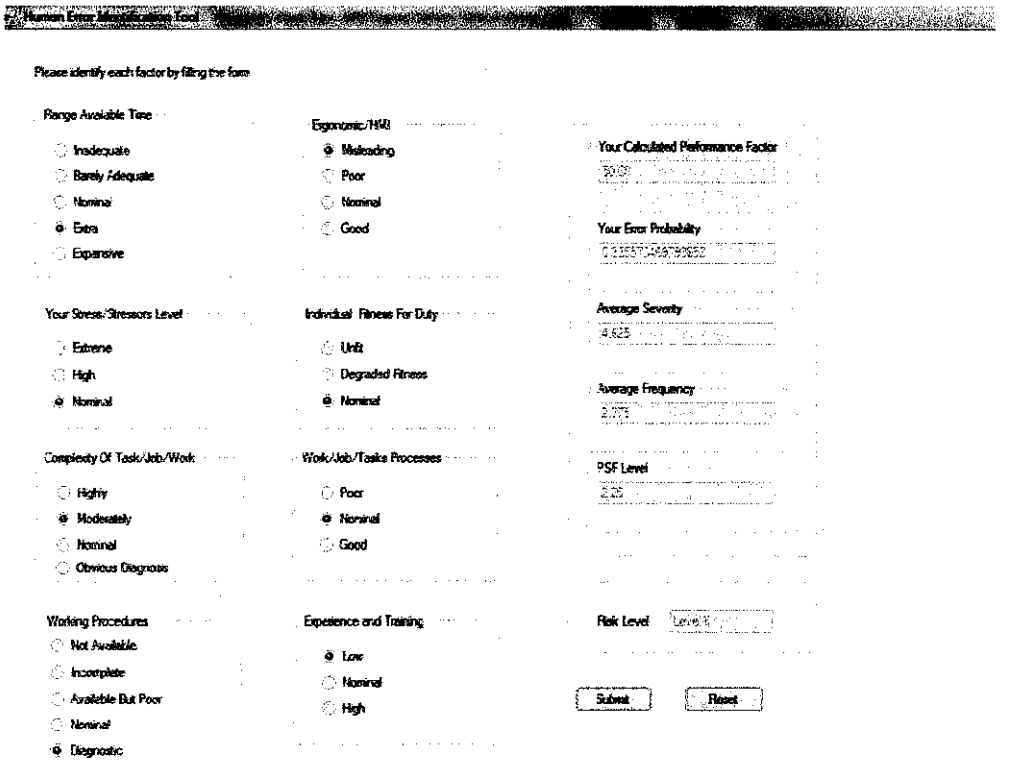


Figure 5: Human Error Identification Tool

This tool is a combination of two methods of human error and risk reliability assessment. The first part which is the calculation of HEP, adapted from one of HRA method, the SPAR-H technique. This method used PSF as factor for determining the HEP value. The calculation and formula used in the coding of this program is validated by calculation of HEP value from the actual source of data, which is from the dissertation of journal by Katrina M. Groth, Dr of Philosophy.2009: A Data Informed Model of Performance Shaping Factor for use in Human Reliability Analysis. The determination of Risk Level is adapted from a journal of Tetsu Moriyama entitled Risk Assessment Tools incorporating Human Error Probabilities in the Japanese small-sized establishment. The method used was numerical scoring method incorporating PSF and the determination of risk validated by using the same formula from the journal.

CHAPTER 5 CONCLUSION AND RECCOMENDATION

CONCLUSION

As chemical industries is expected to be evolving and increasing by years, the implementation of human error identification tools in chemical plant are crucial as a method of reducing and preventing accidents/incidents happen during production process. This type of setback not only might become hazardous to personnel and people involved, but also will affect money, time and production of plant. The execution of human error identification tool in chemical plant may help workers to quickly analyze action that should be avoided before undergoing a process.

This project aim is to develop a human error identification tool that will be used to evaluate error and risk in a chemical industries particularly chemical processing plant. The tool developed is based on past conventional method that has been used widely as error and risk assessment method in other industries such as aviation, healthcare, and nuclear power. The development of human error identification tool is essential as there are still fewer method in quantitative human error analysis for a chemical plant.

The process of data gathering and tool development is still ongoing as there is a lot of information still to be analyzed and summarized before it is finalized. This is because there are not much data on quantitative method for human error identification and also because of the existence of new data in the future that might be helpful to this project. However, the outcome of this project is clear which is to develop a tool for human error identification quantitatively for chemical industries.

The development of Human Error Identification Tool consists of two main output data which is first the human error probability and second is risk level determination. The tool is a simple, easy and practicable for use in chemical plant. This tool aims to assist workers (operators) in plant to evaluate error probability and risk level before the start of the plant operation. With the help of this tool, it is

hopeful that this tool will help to prevent and reduce accident from occurring in processing plant.

RECOMMENDATION

There are several recommendations that can be done to achieve better results for this tool. First, the software Microsoft Visual Basic 2008 is a simple and easy program for beginners to manage a project. A more complex and refined program should be used in order to produce a better and excellence Human Error Tools which will evaluate error probabilities and risk more efficiently with more correct data. Second recommendation is the availability of data that needed for the development of the tool. In this project, the data used is a general for plant cases. For the improvement in future, more data needs to be gathered particularly study case and research involving oil and gas and chemical plant. Although those type of data are still not much, in years to come, the availability of data will helps to develop a more efficient and complete tool in the future.

REFERENCES

1. University of Illinois, 2008, Human Factors Division.
2. U.S. EPA, 2001, Risk Assessment Guidance for Superfund (RAGS), Volume III - Part A.
3. Erik Hollnagel, 2002, Human Reliability Analysis
4. Candice D. Griffith, Sankaran Mahadevan, 2011, Inclusion of fatigue effects in human reliability analysis
5. Harold S. Blackman,David I. Gertman, Ronald L. Boring , 2008 Human Error Quantification Using Performance Shaping Factors in the SPAR-H Method.
6. T. Moriyama and H. Ohtani, 2009, Risk Assessment Tool Incorporating Human error Probabilities in Japanese small size establishment,
7. Katrina M. Groth, A Data Informed Model of Performance shaping Factors for use in Human Reliability Analysis, 2009.
8. Wiegmann, D. A., Zhang, H., von Thaden, T. L., Sharma, G., Mitchell, A. A. A Synthesis of Safety Culture and Safety Climate Research, 2002
9. Melissa T. Baysari , Carlo Caponecchia , Andrew S. McIntosh , John R. Wilson Classification of errors contributing to rail incidents and accidents: A comparison of two human error identification technique, 2008
10. Miroljub Grozdanović, Evica Stojiljković, Framework for Human Error Quantification, 2006
11. Faisal I. Khan Paul R. Amyotte , Dean G. DiMattia, HEPI: A new tool for human error probability calculation for offshore, 2005
12. Jon Espen Skogdalen [n], Jan Erik Vinnem Quantitative risk analysis offshore—Human and organizational factors, 2010
13. Ronald L. Boring, Candice D. Griffith, Jeffrey C.Joe, The Measure of Human Error: Direct and Indirect Perfomance Shaping Factor, 2007.
14. D.G Di Mattia, Prediction of Human Error Probabilities for Muster Action during LNG Tanker Emergencies, 2011.

APPENDIX

Appendix 1 : Tool Coding Form

```
Public Class Form1

    Dim a, b, c, d, q, f, g, h, AP As Decimal
    Dim a1, b1, c1, d1, q1, f1, g1, h1 As Decimal
    Dim a2, b2, c2, d2, q2, f2, g2, h2 As Decimal
    Dim a3, b3, c3, d3, q3, f3, g3, h3 As Decimal
    Dim risk As Decimal


    Private Sub Submit_Click(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles Submit.Click

        BackColor = Color.White

        If R1.Checked Then

            a1 = 10
            a2 = 4
            a3 = 4

        End If

        If I22.Checked Then

            f1 = 10
            f2 = 4
            f3 = 4


        End If

        If R2.Checked Then

            a = 10
            a1 = 10
            a2 = 4
            a3 = 4




        End If

        If R3.Checked Then


            a = 1
            a = 3
            a = 2
            a = 2


        End If
```

```
If R4.Checked Then

    a = 0.1
    a1 = 1
    a2 = 1
    a3 = 1


End If

If R5.Checked Then

    a = 0.01
    a1 = 1
    a2 = 1
    a3 = 1


End If

If Y6.Checked Then

    b = 5
    b1 = 6
    b2 = 3
    b3 = 2

End If

If Y7.Checked Then

    b = 2
    b1 = 6
    b2 = 3
    b3 = 2

End If

If Y8.Checked Then

    b = 1
    b1 = 3
    b2 = 2
    b3 = 2

End If

If C9.Checked Then

    c = 5
    c1 = 6
    c2 = 3
    c3 = 2


End If

If C10.Checked Then

    c = 2
    c1 = 6
```

```
    c2 = 3
    c3 = 2


End If

If C11.Checked Then

    c = 1
    c1 = 3
    c2 = 2
    c3 = 2


End If

If C12.Checked Then

    c = 0.1
    c1 = 1
    c2 = 1
    c3 = 1


End If

If W13.Checked Then

    d = 50
    d1 = 10
    d2 = 4
    d3 = 3


End If


If W14.Checked Then

    d = 20
    d1 = 10
    d2 = 4
    d3 = 4


End If

If W15.Checked Then

    d = 5
    d1 = 6
    d2 = 3
    d3 = 2


End If

If W16.Checked Then

    d = 1
    d1 = 3
```

```
    d2 = 2
    d3 = 2


End If

If W17.Checked Then

    d = 0.5
    d1 = 1
    d2 = 1
    d3 = 1


End If


If E18.Checked Then

    q = 50
    q1 = 10
    q2 = 4
    q3 = 4


End If

If E19.Checked Then

    q = 10
    q1 = 10
    q2 = 4
    q3 = 4


End If

If E20.Checked Then

    q = 5
    q1 = 6
    q2 = 3
    q3 = 2


End If

If E21.Checked Then

    q = 1
    q1 = 3
    q2 = 2
    q3 = 2


End If



If I23.Checked Then
```

```
    f = 5
    f1 = 6
    f2 = 3
    f3 = 2


End If

If I24.Checked Then

    f = 1
    f1 = 3
    f2 = 2
    f3 = 2


End If

If T25.Checked Then

    g = 2
    g1 = 6
    g2 = 3
    g3 = 2


End If

If T26.Checked Then

    g = 1
    g1 = 3
    g2 = 2
    g3 = 2


End If

If T27.Checked Then

    g = 0.8
    g1 = 1
    g2 = 1
    g3 = 1


End If

If TR1.Checked Then

    h = 10
    h1 = 10
    h2 = 4
    h3 = 4


End If

If TR2.Checked Then

    h = 1
```

```
    h1 = 3
    h2 = 2
    h3 = 2


End If

If TR3.Checked Then

    h = 0.5
    h1 = 1
    h2 = 1
    h3 = 1


End If


Text1.Text = a * b * c * d * q * f * g * h

Dim EP As Decimal
'single(7) / double(15) / decimal(29)
EP = (0.01 * Text1.Text) / (0.01 * (Text1.Text - 1) + 1)
Text2.Text = EP

Text3.Text = (a1 + b1 + c1 + d1 + q1 + f1 + g1 + h1) / 8
Text4.Text = (a2 + b2 + c2 + d2 + q2 + f2 + g2 + h2) / 8
Text5.Text = (a3 + b3 + c3 + d3 + q3 + f3 + g3 + h3) / 8


If R1.Checked Then
    a = 1

    Text2.Text = 1

End If

If I22.Checked Then
    f = 1

    Text2.Text = 1

End If


If Text2.Text >= 0.99 And Text2.Text <= 1 Then
    AP = 6
ElseIf Text2.Text >= 0.5 And Text2.Text < 0.99 Then
    AP = 4
ElseIf Text2.Text >= 0.01 And Text2.Text < 0.5 Then
    AP = 2
ElseIf Text2.Text >= 0.000001 And Text2.Text < 0.01 Then
    AP = 1
End If

risk = AP * Text3.Text * Text4.Text * Text5.Text

If risk >= 480 And risk <= 960 Then
    Text6.Text = "Level IV"
ElseIf risk >= 70 And risk < 480 Then
    Text6.Text = "Level III"
```

```
        ElseIf risk >= 25 And risk <= 69 Then
            Text6.Text = "Level II"
        ElseIf risk <= 24 Then
            Text6.Text = "Level I"
        End If



        If a = 0 Or b = 0 Or c = 0 Or d = 0 Or q = 0 Or f = 0 Or g =
0 Or h = 0 Then
            Text1.Text = ""
            Text2.Text = ""
            Text3.Text = ""
            Text4.Text = ""
            Text5.Text = ""
            Text6.Text = ""
            R1.Checked = False
            R2.Checked = False
            R3.Checked = False
            R4.Checked = False
            R5.Checked = False
            Y6.Checked = False
            Y7.Checked = False
            Y8.Checked = False
            C9.Checked = False
            C10.Checked = False
            C11.Checked = False
            C12.Checked = False
            W13.Checked = False
            W14.Checked = False
            W15.Checked = False
            W16.Checked = False
            W17.Checked = False
            E18.Checked = False
            E19.Checked = False
            E20.Checked = False
            E21.Checked = False
            I22.Checked = False
            I23.Checked = False
            I24.Checked = False
            T25.Checked = False
            T26.Checked = False
            T27.Checked = False
            TR1.Checked = False
            TR2.Checked = False
            TR3.Checked = False
            MsgBox("Please answer all question!")

        End If

    End Sub

    Private Sub Text1_TextChanged(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles Text1.TextChanged


    End Sub
```

```
    Private Sub Text2_TextChanged(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles Text2.TextChanged

    End Sub

    Private Sub Form1_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Load

    End Sub

    Private Sub Reset_Click(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles Reset.Click

        Text1.Text = ""
        Text2.Text = ""
        Text3.Text = ""
        Text4.Text = ""
        Text5.Text = ""
        Text6.Text = ""
        R1.Checked = False
        R2.Checked = False
        R3.Checked = False
        R4.Checked = False
        R5.Checked = False
        Y6.Checked = False
        Y7.Checked = False
        Y8.Checked = False
        C9.Checked = False
        C10.Checked = False
        C11.Checked = False
        C12.Checked = False
        W13.Checked = False
        W14.Checked = False
        W15.Checked = False
        W16.Checked = False
        W17.Checked = False
        E18.Checked = False
        E19.Checked = False
        E20.Checked = False
        E21.Checked = False
        I22.Checked = False
        I23.Checked = False
        I24.Checked = False
        T25.Checked = False
        T26.Checked = False
        T27.Checked = False
        TR1.Checked = False
        TR2.Checked = False
        TR3.Checked = False
    End Sub

    Private Sub W13_CheckedChanged(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles W13.CheckedChanged

    End Sub

    Private Sub Y6_CheckedChanged(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles Y6.CheckedChanged

    End Sub
End Class
```