FRAMEWORK FOR PERMIT TO WORK ASSESSMENT

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DEDICATION

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ABSTRACT

Permit to work (PTW) is an official document used as a means of communication, control, and managing work activities to prevent accidents at petrochemical plants. However, there are cases whereby the PTW has failed to control work activities resulting in occupational accidents. Hence, this study was conducted to develop a framework for permit to work assessment related to occupational accidents in petrochemical plants. For this assessment, the PTW and occupational accidents questionnaires were verified by expert panels according to Delphi technique for five (5) selective PTW elements, i.e. hazardous activity, worksite inspection, supporting document, work description, and closeout. A total of 260 survey questionnaires were distributed to work leaders and workers at the selected plants. The data were analyzed using the exploratory factor analysis and confirmatory factor analysis methods. Next, a structural equation model (SEM) was employed to identify the most significant element(s) related to the failure of PTW. The assessment results revealed that hazardous activity was the leading cause of occupational accidents in petrochemical plants. The SEM results were validated using the fault tree analysis technique, which indicated that the same rank of factors contributed to the occupational accident. In addition, a simple multilinear regression of the PTW element was used to develop predictive modelling, which was validated using a case study. Finally, the framework for permit to work assessment of occupational accidents in petrochemical plant has been developed. This framework can be further developed to extend the PTW assessment of occupational accident from other types of industry.

ABSTRAK

Permit kerja (PTW) adalah dokumen rasmi yang digunakan sebagai cara komunikasi, kawalan, dan pengurusan aktiviti kerja untuk mencegah kemalangan di loji petrokimia. Walau bagaimanapun, terdapat kes di mana PTW gagal untuk mengawal aktiviti kerja yang mengakibatkan kemalangan pekerjaan. Oleh itu, kajian ini dijalankan untuk membina kerangka untuk menilai unsur- unsur PTW yang berkaitan dengan kemalangan pekerjaan dalam aktiviti di loji petrokimia. Soal selidik telah dibangunkan menggunakan kaedah Delphi dan disahkan oleh pakar penilai untuk memilih lima (5) unsur- unsur PTW yang berkaitan iaitu aktiviti berbahaya, pemeriksaan tapak kerja, dokumen sokongan, huraian kerja dan penutupan kerja. Sejumlah 260 set soalan kaji selidik diedarkan kepada pemimpin pekerja dan pekerja di kilang yang terpilih. Data dianalisis dengan menggunakan kaedah analisis faktor eksplorasi dan analisis faktor pengesahan. Seterusnya, satu model persamaan struktur (SEM) digunakan untuk mengenal pasti unsur yang paling penting berkaitan kegagalan PTW. Hasil penilaian menunjukkan bahawa aktiviti berbahaya adalah punca utama kemalangan pekerjaan dalam loji petrokimia. Hasil SEM telah disahkan menggunakan teknik analisa pokok kesalahan yang juga menunjukkan faktor yang sama menyumbang kepada kemalangan pekerjaan. Di samping itu, regresi multilinear mudah dari unsur unsur PTW digunakan untuk membangunkan pemodelan ramalan yang telah disahkan menggunakan kajian kes. Akhir sekali, kerangka penilaian permit kerja telah dihasilkan. Kerangka ini boleh ditingkatkan lagi untuk penilaian permit kerja dalam kemalangan pekerjaan untuk lain-lain industri.

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LIST OF ABBREVIATIONS

AIChE	-	American Institute of Chemical Engineer
AMOS	-	Analysis of Moment Structure
CB		Covariance Based
CCPS	-	Centre Of Chemical Process Safety
CFA	-	Confirmatory Factor Analysis
CO	-	Closed Out
DOSH	-	Department of Safety and Health
DV	-	Dependent Variable
EFA	-	Exploratory Factor Analysis
ePTW	-	Electronic Permit To Work.
FAC	-	First Aid Case
FTA	-	Fault Tree Analysis
HIRARC	-	Hazard Identification, Risk Assessment, Risk Control
HSE	-	Health Safety and Environment
IV	-	Independent Variable
JHA	-	Job Hazard Analysis
KMO	-	Kaiser Meyer Olkin
LEL	-	Lower Explosive Limit
LOPC	-	Loss of Process Containment
NPD	-	Non-permanent Disability
MOC	-	Management of Change
MS	-	Malaysian Series
OA	-	Occupational Accident
OHSAS	-	Occupational Health Safety Assessment Series
OSH	-	Occupational Safety and Health
OSHMS	-	Occupational Safety and Health Management System
PD	-	Permanent Disability
PHA	-	Process Hazard Analysis
PPE	-	Personal Protective Equipment.

PTW	-	Permit To Work
PSM	-	Process Safety Management
SEM	-	Structural Equation Model
SD	-	Supporting Document
SHA	-	System Hazard Analysis
SHIPP	-	System Hazard Identification, Prediction and Prevention
SPSS	-	Statistical Package for the Social Science
SSOW	-	Safe System of Work
WD	-	Work Description
WI	-	Worksite Inspection

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Permit To Work (PTW) is an official document and an essential part of a safe work system. PTW is one of the elements in Process Safety Management (PSM). It is being used in many industries to control their work activities in their day-to-day operation to ensure safe operation. The PTW provides steps for authorizing the person to carry out work while warning them of possible hazards and spelling precautions needed to work safely. It is used to control high-risk activity by managers or supervisors in most industries and allow a person or group to carry out the task under strict control to protect workers from unexpected accidents. In addition, PTW becomes a communication tool between works parties in the installation. Typically, contractors or workers can only be allowed to execute any work after the PTW application has been approved and when all procedures are clear and foreseeable hazards have been taken into consideration.

1.2 Background of the Study

The PTW is used widely in the oil and gas industries, such as petrochemical plants and offshore platforms. The PTW system is required for any hot or cold work such as preventive maintenance, blasting, painting, lifting activity, valve, or piping replacement. The usage of PTW increases during the turnaround activities in petrochemical plants. Typically, the work leader or area operator involved in daily activities must check all hazardous activities and perform a site inspection. In addition, the designated staff must ensure that all works associated with hazards are managed to the lowest possible level before approving the PTW. In the plant, the PTW system involves managing and controlling potentially hazardous work activities minimize identified risks and ensuring that the job is conducted safely without an accident. But somehow, the accidents that occurred in industries are highly concerned and worried by many parties in the industry. One of the accident-contributing factors is due to failure of the PTW system. Yan et al., (2017) state that the contribution of PTW failure in the process safety accident in the chemical process industry is about 7 %, as outlined in Table 1.1. The Process Safety Management (PSM Standard 1992) requires employers to develop and implement safe work practice using the PTW for ensuring that accident does not happen at the workplace.

Table 1.1 Percentage of accidents due to PTW in PSM (Yan et al., 2017)

PSM Element	PSM element number	Contribution to the accident (%)
Employee participation	1	13.2
Process safety information	2	5.6
Process hazard analysis	3	16.2
Operating procedure	4	16.8
Training	5	11
Contractor	6	2.5
Pre-start-up safety review	7	1.6
Mechanical integrity	8	9.2
Hot work permit	9	7.0
Management of change	10	8.2
Incident investigation	11	4.0
Emergency planning & response	12	2.7
Compliance audit	13	1.0
Trade secrets	14	0.8

There is also the occupational accident occurred in the industry. Occupational Accident Statistic by state Jan – July 2020 (Reported to DOSH) as illustrated in Table 1.2, the occupational accident occurred in Malaysia. The total of occupational accidents of all states is 4125, with Johor indicating the higher NPD with 647 cases, PD was 33 cases, and deaths were 29 cases with a total of 709.

Table 1.2 The occupational accident in Malaysia (DOSH 2018 report)

State	Non-Permanent Disability	Permanent Disability	Death	Total
Johor	647	33	29	709
Kedah	204	10	2	216
Kelantan	55	2	2	59
Melaka	195	4	3	202
N. Sembilan	233	12	2	247
Pahang	222	8	9	239
Perak	438	13	1	452
Perlis	18	-	-	18
Pulau Pinang	409	12	7	428
Sabah	130	9	15	154
Sarawak	221	11	15	247
Selangor	886	29	20	935
Terengganu	65	-	5	70
WP K. Lumpur	135	2	3	140
WP Labuan	8	1	-	9
Total	**3866**	**146**	**113**	**4125**

1.3 Problem Statement

The Social Security Organization (SOCSO) states that the total accident cases reported in 2016 were 66,618 cases comprising 35,304 industrial accidents and 31,314 commuting accidents. In the OSH 2018 report, the fatality rate was 4.14/100,000 workers, indicating that the occupational accident trend is somewhat alarming. In Section 15 of OSHA Malaysia (1994), an employer or a self-employed person should provide a safe workplace. Likewise, the employees are mandated to adhere to all the safety regulations to ensure a safe workplace.

Since some occupational accidents in plants were suspected related to the PTW implementation, it is considered an essential part of managing work activities with high prospects of accidents compared to routine or daily work. The need to have an appropriate PTW system is to prevent accident occurrences. Typically, about 30 % of all reported accidents within the chemical industry are related to maintenance works or “dangerous activity”. For example, these mishaps arise from failure to correctly implement safety guidelines or reports from the previous investigation. Furthermore, previous accident reports in the petrochemical industry revealed that one of the accident factors was poor management or adherence to PTW.

Poor operation or lack of PTW system accounts for over 20% of all the accident cases investigated in the chemical industry. The Piper Alpha tragedy (1996) and the Bhopal accident (1984) have become the turning point for safety practitioners and safety experts to look back on the PTW system. Hence, comprehensive reviews to improve all PTW management systems, including the PTW process, procedures, and approval, are required before working in a petrochemical plant. In the Piper Alpha accident, it was revealed that the PTW failed to ensure proper communication between working parties on the installation. The PTW was unable to become a barrier to prevent an accident. The PTW does not function properly to maintain safe work practices among workgroups and has failed to become a communication tool in the plant.

Furthermore, the weakness of the PTW management system caused many occupational accidents to occur. During process operation, maintenance, or construction, plant workers' accidents occurred during routine or non-routine work or shutdown activities. In the past decade, many efforts have been implemented to prevent accidents in the best possible way. However, the injuries and deaths due to the occupational accident still occurred in the petrochemical plant. The effort did not produce the expected results with the high accident record, which is worrying and unacceptable.

1.4 Research Goal

The study aims to improve occupational safety from the perspective of PTW, and three detailed objectives were outlined as follows:

a) To identify and select PTW elements.

b) To perform the PTW assessment using Structural Equation Model, predictive model and validate with the case studies.

c) To develop a framework for PTW assessment.

1.5 Scope of the Research

The researcher started the study by developing a questionnaire for selecting the right PTW element. The questionnaire consists of items and the suitability of the constructs. The three-round Delphi Technique was used to evaluate the construct. This technique requires several rounds of questionnaires sent to safety experts to obtain their consensus before the questionnaire finally be used in the pilot and actual study. The safety experts involved are the Safety and Health Officer (SHO), Safety Supervisor, Safety Manager and Operation Supervisor. After the expert's consensus approved questionnaire and items, the questionnaire was distributed to work leaders of the contractors in the petrochemical plant. A pilot study collected one hundred samples from the work leader and workers in the east coast Malaysia petrochemical plant. As an initial test procedure, a pilot study was conducted to examine the feasibility of an approach intended for the actual survey.

After the pilot study, the questionnaire was distributed to 260 personnel at the plant for the actual survey. The population sample consists of work leaders and workers in the oil and gas sector at several petrochemical plants in Kerteh Industrial Area, Terengganu, Malaysia. Then the factor analysis was carried out for the statistical analysis, which involved the Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA) and Structural Equation Model (SEM) with Amos IBM software. It calculates the regression coefficient at each path in the structural model. Based on regression value, hypothesis testing was determined whether there is a significant effect on each model path or examined. The PTW elements selected in this study such as Work description (WD), Hazardous Activity (HA), Worksite Inspection (WI), Supporting Document (SD) and Closed Out (CO). Subsequently, the SEM assessment results were compared and validated by Fault Tree Analysis (FTA).

The FTA was constructed based on the questionnaire item for the assigned probability calculation for each construct item to validate and ensure the correctness of the SEM result. The predicted model based on SEM results analysis using multiple linear regression techniques was derived to predict the occupational accident. The output of the SEM was used to predictive the occupational accident. Then the SEM was applied to validate the case study. The literature's probability data was used to validate the model. Finally, the framework for PTW element assessment was developed.

1.6 Significance of the Study

The findings benefit the oil and gas industry, considering that PTW plays a vital role in workplace accidents prevention. Developing construct and items in a questionnaire with the safety expert's consensus and applying the structural equation modelling (SEM) for the occupational accident prediction. Hence, using the SEM in modelling latent is the main contribution of this study. The discovery also enables stakeholders to conduct a risk assessment and guide users to comply with PTW. The new PTW elements and predictive model can be used to reference future PTW studies. This study is significant as a framework for the assessment of the PTW work documentation and procedure to be implemented in many industries. Lastly, the study may help prevent accidents early by strictly adhering to the PTW elements and sub-elements before granting PTW approval to work leader and workers.

1.7 Novelty of the Study

The novelty of this research can be described as the development of a new PTW assessment framework, which is a central topic of this study. This PTW Assessment Framework can be used for reference and guide people to perform the proper PTW assessment at their respective workplaces and in the industry.

1.8 Thesis Outline

The thesis is divided into five (5) chapters. Chapter 1 introduces the background of the study related to Permit To Work (PTW), including the problem statement, objectives, scopes, significance, and the novelty of the study. Chapter 2 is a literature review for the previous research, consisting of PTW element, occupational accident, factor analysis, including structural equation model and predictive modelling until the formation of PTW framework assessment. Chapter 3 cover the framework for PTW assessments methodology. Chapter 4 presents the results covering all the objectives, and lastly, Chapter 5 summarizes the conclusions and recommendations for the future study.

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