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Original

Factors Affecting Performance of Permit to Work System: A Case Study in an Oil Refinery

Seyed Mahdi Mousavi [1], Ali Karimi [1*], Seyed Abolfazl Zakerian [1], Mahsa Jahadi Nacini [2]

[1] Department of Occupational Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran [2] Department of Occupational Health Engineering, School of Public Health, Isfahan University of Medical Sciences, Isfahan, Iran *Corresponding Author: Ali karimi , E-mail: a_karimi @ sina .tums.ac ir, Tel:+98-21-55951390

Abstract

Background: Permit to Work system is a documented system to control activities that are inherently hazardous and may cause incidents. The aim of this study was to evaluate performance of Permit to Work (PTW) system in an oil refinery. **Methods:** The Study was a cross-sectional study that was done during 2019 in one of the oil refineries in southern Iran. A total number of 125 participants who were experts that were working in an oil refinery and were in charge of Permit to work (PTW) issuing, were selected based on census method and were entered into the study. The instrument of this study was a questionnaire about evaluating performance of Permit to work system, which was completed by the participants after explaining the aim of the study and training them how to complete it. In order to data analysis SEPPTW software was applied. **Results:** The results showed that the performance of Permit to work system in the studied refinery is generally in the moderate level (41.2 score). Also, in the field of hazard identification and risk assessment, the performance of Permit to work system was poor, but its performance in the field of coordination and informing was at a good level. **Conclusion:** Identifying the weak points and causes of defect in Permit to work system can result in increased levels of Permit to work system, and then reduced incidents from work related to permit to work in process industries.

Keywords: Permit to work system; Performance evaluation; Oil refinery

Introduction

Process incidents often occur in industries such as oil, gas, petrochemical, and chemical industries, that are one of the most important and obvious causes of human, financial, and environmental damages in industries. In process industries, there is significant amount of flammable and toxic substances, and these substances cause that the potential of incident occurrence in these industries is high.[1-4] The explosion at the Alfa Piper platform, the explosion at oil refinery Amuay in Venezuela, and the explosion in Texas in US, are the examples of process incidents that has happened in various countries in recent years. In our country, process incidents have taken place in recent years, such as the explosion at Bandar Mahshar Petrochemical and the fire at Bu Ali Sina Petrochemical, which resulted in many casualties, environmental damages and billions of dollars financial losses.[5-10] The results of studies on the causes of incidents in process industries showed that it is mainly related to maintenance and repair

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activities, and one of the most important main reasons of these incidents is a defect or lack of Permit to work system.[11]

Permit to work system is a documented system that is applied to control activities that are potentially hazardous and have the potential to cause incidents. This system is a means of communication between site management, plant supervisors and operators. By correctly establishing of this system, we can prevent these type of mistakes that result in catastrophic incidents that have the potential of the person's injuries, equipment and environmental damages. In other words, permit to work system with a systematic approach seeks to eliminate and reduce human errors and risks from different work activities.[12, 13] The results of Frank Liss study showed that Permit to work system in the process industries has shortcomings and problems in the Permit to work form, training of individuals, hazards identifications, separation methods, time limitation, work shift method, and implementation of repaired equipment.[14] The Scott Teas research found that 20 percent of the incidents that occur during the maintenance and repair operations in chemical industries, are the incidents that are related to permit to work system. Qahramani also discussed about the monitoring the conformity of this system condition to audit criteria in an oil and the gas operational company and stated that there is a significant gap between these audit criteria and audit evidence; so that the examined system is non-compliance with the training and qualifications, coordination and monitoring. Yan et al., extracted and analyzed the data recorded by EMARS (European Major Accident Reporting System) and FKD (Failure Knowledge Database) from 1999 to 2015, and claimed that organizational factors, equipment, incompetence of individuals, lack of monitoring during the work, and incidence of human error is one of the most essential causes in the deficiency of performance in Permit to work system.[15]

Iran as a developing country, has several large and small industries related to oil, gas and petrochemical. Statistics showed that around 210,000 workforces in Iran are working for oil, gas and petrochemical industries and the severity of the incidents and damages from this work is reported extremely high,[16, 17] so that the need for more attention to the Permit to work system seems necessary. According to the importance and role of permit to work system in incidents preventions in process industries, performance evaluation of this system in order to identify of strengths and weaknesses to improve its performance is very important.

Methods

This study is a cross-sectional study that was done in 2019 in an oil refinery in southern Iran. The statistical population of this research is 125 operational workforces. The entrance criteria for this study were, at least 5 years of work experience in the field of Permit to work and membership in the team of oil refinery permit to work during the study and willing to cooperate. All the participant in the study were volunteers and the individuals that didn't meet the inclusion criteria were excluded from the study. Before starting the evaluation, the aim of the study and explanation about how to complete the questionnaire before the study were cleared for all the present staff. Reluctant to participate is the criterion of excluding from the study. The instrument of the present study is a questionnaire on evaluating performance of Permit to work system that has been evaluated by the authors of this study for its reliability and validity. Also, in order to data analysis, evaluating performance of the Permit system software was used.

Performance Evaluating Questionnaire

Performance evaluation Questionnaire of Permit to work system includes 50 questions and assess permit to work in six evaluation areas: Risk (10 questions),

risk prevention and control (18 questions), accountability (4 questions), coordination (6 questions), clarification (6 questions), documentation (6 questions). Table 1 shows the reason for the importance and necessity of examining of the mentioned areas when evaluating permit to work system performance.

In this questionnaire, experts and evaluators of permit to work system are asked to explain their viewpoints on the implementation process of work to permit system by using of 5-point Likert scale (very low, low, medium, high, very high). The total score of this questionnaire is obtained from the following equation1.

Σ risk assessment score + Σ risk prevention and control score + Σ accountability score + Σ coordination score + Σ clarification + Σ documentation = Permit to Work system score

Finally, based on the obtained score, the performance of this system in each of the six areas and generally in one of the levels includes excellent (76 to 100), good (51 to 75), average (76 to 100) and poor (25 and less) is located. The reliability of the evaluation questionnaire of Permit to Work System was assessed using the Cronbach's alpha test by Karimi et al., in an oil refinery, and it was equal to 0.81.[18]

SEPPTW Software (Software for evaluating the Performance of Permit to work System)

Software for evaluating the performance of Permit to work system has two types of user environment, Admin and User environment. By entering into the workplace, Admin defines the profile of users and their access limit, and allows them to perform the assessment. Users complete their electronic Permit to work system questionnaire by entering into the software environment. Notification of completed questionnaire by all users is sent through database to the admin system, and finally, the software analysis the input data. Software output includes the total score of organization that identified in 6 effective criteria or areas, which indicates the status of the organization in the correct implementation of Permit to work system. Also, this software has the ability to assess the shortcomings and the level of performance of Permit to work system based on the received scores for each question.

Results

The mean age and standard deviation of the participants in this study were 41(24.6), and the mean and standard deviation of work experience was 11(4.1). Other demographic characteristics of experts who completed the Permit to work system performance assessment questionnaire are shown in Table 2.

Table 1. Present performance evaluation questionnaire and the importance of them in the Permit to work system.

	Area	Importance in permit to work system
1	Risk assessment	Is a critical element in permit to work system that is the main key in identifying and evaluating potential risks that may occur when doing work?
2	Risk prevention and control	There are set of recommended measurements to control before Permit to work that is done based on the definition of the risk assessment and recorded in Permit to work.
3	Accountability	Performance and efficiency of a system depend on accountability of the members of the system.
4	Coordination	Because of the involvement of a large number of individuals in this system or other people who somehow involve in this system, coordination in informing is very important in this system.
5	Clarification	In the permit to work system, efforts should be in a way that permit to work forms are understandable for all people.
6	Documentation	Since the permit to work system includes the critical guidelines, the importance of documentation cannot be ignored.

Table 2. Demographic characteristics of the study participants (N=125)

Variable		Frequency	Percent
Age(years)	30-35 years	28	22.4
	36-40 years	37	29.6
	41-45 years	48	38.4
	46-50 years	12	9.6
Work experience(years)	5-10 years	32	25.6
	11-20 years	53	22.4
	21-25 years	28	22.4
	26-30 years	12	9.6
Qualifications degree	Diploma	30	24
	Bachelor	75	60
	Master	14	11.2
	Phd.	6	4.8
Job	Head of unit	6	4.8
	Safety officer	25	20
	The shift manager	10	8
	Senior employee	27	21.6
	Site employee	15	12
	Control room employee	17	13.6

Table 3. Mean score and performance status of permit to work system in different areas based on collected ideas of participants in the study

Performance status	Mean score obtained	Maximum score to be achieved	Areas of Permit to work system
Poor	4.6	18	Hazard identification & Risk Assessment
Medium	6.5	18	Prevention & Risk Control
Medium	7.2	19	Accountability
Good	9.9	15	Coordination and Informing
Medium	6.3	15	Documentation
Medium	6.7	14	Clarification
Medium	41.2	100	Permit to Work System

Table 4. Classification of identified deficiencies based on performance assessment of Permit to work system.

Areas	Defects identified in the system
Hazard identification & Risk Assessment	Lack of mastery and insufficient familiarity of permit to work issuers with risk identification and risk assessment methods Identifying hazards while visiting the workplace Failure to include assessing risks on the Permit to work sheet Failure to performing gas metering periodically
Prevention & Risk Control	Lack of proper selection of safety equipment Lack of necessary inspections and forecasts Wrong choice of personal protective equipment
Accountability	Failure to register and lack of signature of the issuer and executor
Coordination and Informing	Lack of coordination with other work-related unit Lack of coordination between the executors
Documentation	Lack of archiving of Permit to work Failure to follow the documentation instructions Non-return of completed Permit to work sheet
Clarification	Wrong date record Presence of scratches The illegibility of Permit to work vague registration of the workplace

The results of 125 questionnaires using Permit to work evaluation software showed that the performance of Permit to work system in 4 areas is medium and in one area is poor and in another area is good. Also, the total score of the system was 41.2 which indicates medium performance level. More details about the obtained score and status of permit to work performance in each area is shown in Table 3.

The reasons for the errors and the decrease in the level of performance of Permit to work system in each of the six areas based on completed questionnaires by the participants in the study were identified. In the hazard identification and risk assessment area, unfamiliarity of permit to work issuers with risk identification and risk assessment methods, failure to visit of the site to risk evaluation and risk identification, failure to include assessed risks on the Permit to work sheet, and failure performing gas metering periodically, are the most important causes of decreased performance level of Permit to work system in the area of Hazard identification and risk assessment that are identified. Other causes for the reduced performance level of Permit to work system according to the study area separately are shown in Table 4.

Discussion

The aim of this study was to evaluate the performance of the Permit to work system in an oil refinery in southern Iran. Instrument used in this study was the questionnaire of the Permit to work system performance. This questionnaire evaluates the Permit to work system based on 6 areas include, risk assessment, prevention and risk control, accountability, informing and coordination, clarification, and documentation, which was evaluated in the form of 50 questions, and finally performance level of Permit to work system based on the sum of the scores received in each of the studied dimensions determined. The results of 125 collected questionnaires that were completed by the experts in this study showed that the performance of Permit to work system in the studied refinery in the area of identifying and risk assessment is poor. One of the most essential causes of deficiency in Permit to work system is that identification of risk and risk assessment should be done before issuing Permit to work with the person who is issuing the Permit, however, because of negligence and human errors, identification and risk assessment is not done based on principles.

In his study, Jahangiri examined the role of human error in issuing Permit to work in the petrochemical industry. His study results showed that the maximum and the minimum possibility of human errors among job duties of issuing Permit to work is related to the job of testing flammable gases, toxic gas testing, and oxygen testing, respectively. In this study, emphasize was in the presence of an engineering approach in human error evaluation that may happen during the issuing Permit to work process and decreased the efficiency of Permit to work system.[19] Qasemi et al., in their study entitled "Classification of Human Errors in the Issuing Permit to Work Process in a Petrochemical Industry Using the SHERPA Method", concluded that despite of presence of the Permit to work system to control non-routine activities with high incident statistics, human errors have a main role in the failure of Permit to work system.[20]

The person who is in charge of issuing Permit to work should write preventive measures that must be considered during the work. Also, the person must make sure that the conditions to implement the recommended measures are available. One of the main reason for the reduced performance level of Permit to work system in studied refinery in the area of prevention and risk control is because of weakness of staff in the field of risk identification and risk assessment. In Mirderikvand study that has done using HSEK-UK audit checklists in an oil platform company, found that failure to risk assessment, no insertion of the necessary precautions measurements, and lack of a method to evaluate the qualification of signatories of Permit to work are three main non-compliances in the Permit to work system, which is inconsistent with the present study.[21] Because of the large number of people who directly and indirectly involve in the Permit to work system, it is important to have effective communication between people. Also in this system, duties and responsibilities of each one of the individuals should be clearly defined.

In the area of accountability and clarification, system performance was evaluated at a medium level. Since this system has different guidelines as well as the records of people involving in the system, it should have a desired performance in the area of documentation. The level of Permit to work system in the studied refinery was assessed as medium. Qahramani in his study using SHELL checklists, examined the amount of compliance of the current condition of Permit to work system with the audit criteria. Lack of documentation system, and lack of identifying responsibilities are the most causes of non-compliance, which is inconsistent with the current study. The different instrument used as well as the desired industry can be one of the reasons of inconsistency. Although, in both instruments addressed the importance of documentation and specifying responsibilities in the Permit to work system.[22] In order to evaluate Permit to work system five criteria include system, training and qualification, Permit to work, coordination and control used, and finally, based on the mean score obtained in each criterion, general status of Permit to work system in four categories includes, very poor, poor, medium, good is classified.[23] Another present instruments to auditing and evaluating compliance of Permit to work system with the regulations and guidelines for issuing Permit is Level 2/3/4 Audits checklist belongs to the SHELL Oil Company. This checklist includes questions in the areas of system, documentation, training and qualification, Permit to work form, coordination and control, and isolation. In this checklist score 5 indicates good performance of the system.[21]

The introduced checklists are for daily control of the issued Permits in the workplace and the responses consist of "yes", and "No". Since the answer to some questions is not definite and the respondents cannot express their idea with certainty, and "yes" and "no" answer indicates certainty in a specific subject, so, answering to the questions of performance evaluation cannot explain the present status. Therefore, there is a need to create a Likert spectrum in order to improve the answering process, so in this study, a performance evaluation questionnaire was used as a Likert scale. One of the strengths of the present questionnaire is examining the instructions and guidelines for issuing Permit to work inside and outside the country, as well as this instrument by interviewing academic and industrial experts in various fields raises questions and the collected answers can show the weaknesses of the system. In addition, SEPPTW software with an easy user interface can cause speed up and facilitate the electronic questionnaire of performance evaluation of Permit to work system, and eliminate the need to use other software in statistical analysis.

Conclusion

The results showed that the performance of Permit to work system in the studied oil refinery is moderate. Also, performance of Permit to work system in the risk identification and risk assessment are is poor and in the accountability area is good. So, to improve the present status, it is needed for holding retraining classes on issuing Permit to work and identifying the appropriate training topics and managers and safety supervisors of the refinery have to consider the planning to reduce causes of errors in Permit to work system. Also, the achieved results of this study can be used by managers and safety supervisors in similar process industries such as petrochemical and gas as a guide to evaluate and identifying errors that can cause defects and reduce the effectiveness of the Permit to work system in preventing incidents in process industries.

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