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Management of Change System with Integrated Risk Analysis for Temporary and Emergency Cases

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ABSTRACT

The potential of a major accident may significantly increase when change is unprepared especially in a temporary and emergency change. An unplanned change may lead to the emergence of new hazards which eventually lead towards severe impact on human, property, environment and business reputation. Management of Change (MOC) with integrated risk analysis is an important Process Safety Management (PSM) elements involving planning and controlling risks and hazards that come with the proposed change. However, lacking systematic technique for easy adoption of this element has delayed its application in plant. Corresponding to these weaknesses, an integrated MOC management system focusing on the temporary and emergency change is presented in this study. Results of this study comprise MOC process framework and MOC management system (MOCMS) which act as a guidance and documentation inventory tool. Implementation of this technique and system at the selected plant as a case study is examined and discussed. The system is beneficial to industries to manage underlying risks in a temporary and emergency change which ease the tracking of MOC case inventory to improve risk controls in changes.

Keywords: Emergency change, management of change (MOC), process safety management (PSM), temporary change

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INTRODUCTION

Nowadays, highly hazardous industries grow rapidly due to the increasing demand towards petroleum made products. Technologies and manufacturing process in these industries are getting complex to improve productivity in order to meet the market demand, aiming to remain competitive. Potential of disastrous

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events may significantly increase following the growing complexity and expansion of operation process. In the business world, the successful enterprise should have the ability in managing and exploiting changes effectively, turning the unpredictable situation into business opportunities. Therefore, enterprise requires an effective Management of Change (MOC) system to survive in this ever-changing world. MOC possesses an advantage not only applicable to process safety but also in terms of business perspective. MOC system covers planning and proposing of tactical control actions on potential risk (Kontogiannis et al., 2017; Kuivupalo et al., 2015). Managing the change is challenging as it requires quick disseminate of related knowledge and information to address the hazards. Reporting and reviewing task may be complicated as more paperwork is required. Moreover, applying changes on operation process is complex procedures and relatively challenging which requires assessing the need for improvements and training of personnel, to meet potential challenges and so on. Period of change required varies according to the situation. It may come as permanent, temporary or only during an emergency.

The temporary change is the change required for a specific duration up to several months meanwhile emergency change is required when the situation goes beyond control from the safety perspective and has been declared as an emergency in emergency response procedure (Centre for Chemical Process Safety, 1995). Bypassing process or maintenance repair are the common temporary or emergency changes which appear in the process plant (Harrison, 2012). Looking back on a few previous major industry tragedies such as Flixborough in 1974, Bhopal in 1984 and many more, these incidents mainly occurred due to unplanned temporary MOC (Bowonder, 1987). Example of temporary change is well portrayed from the Flixborough incident. There was a temporary change on the reactor to complete maintenance of corrosion. This temporary change was not well controlled and contributed to the happening of the explosion (Siong et al., 2017). MOC is the element which is worth for the employer to pay attention to. This can be seen from the statistics presented by previous studies where 19% of process safety accidents occurred due to poor MOC program (Siong et al., 2017; Ye et al., 2012). Approximately 80% of major accidents traced showed MOC failure as the root cause. In every 1000 work tasks, there would be 5-10% of tasks requiring MOC with 5 to 10 changes are high risk (Gambetti et al., 2013).

Importance of MOC was discovered by many international organizations in recent years. There were several standards and regulations established such as ISO 45001 and Process Safety Management (PSM) regulation which included MOC as one of the 14 elements. US Occupational Safety and Health Administration (OSHA) established the PSM standards in February 1992 entitled “Process Safety Management of Highly Hazardous Chemicals, 29 CFR 1910.119”. It is one of the common standards referred in PSM implementation and practice. 29 CFR 1910.119 incorporated a total of 14 elements to manage all aspects in industry to cover almost every aspect of safety management (OSHA,

2013). PSM improves safety performance proactively at developed country such as U.S as well as developing country (Anwar et al., 2019). MOC is an interdependent element where several elements work together to provide sufficient evidence for the decision-making phase. MOC is interrelated with at least 10 elements in PSM including Process Hazard Analysis, Process Safety Information, Mechanical Integrity, Employee Participation, Incident Investigation, Compliance Audit, Pre-Startup Safety Review, Contractor, Training and Operating Procedure (Aziz et al., 2016).

MOC process requires long lead time due to several factors. A meeting should be conducted with the affected departments and specialist to address the control measure on the potential risk in the change. Documents related to process hazard analysis (PHA), process safety information (PSI) and other elements are required to review and evaluate the change. Lastly, documentation for all related work task and risk assessment is required for both temporary and permanent changes. Unfortunately, current MOC approaches are having limitation in time constraint and urgency to resume operation which contributes to failure. This is obviously time consuming to perform all the steps especially for temporary and emergency MOC changes (Gambetti, 2013). As a result, simplification on risk assessment and the absence of updating operating procedure were elements that were neglected in MOC due to urgency (Siong et al., 2017). There exists a major weakness on MOC effectiveness in current practice which is poor documentation where tracking of MOC cases are building up the number of incomplete MOC cases, which may eventually turn incomplete temporary changes into a potential hazard on the premise (Chosnek, 2010).

Despite having established PSM standard, a method for integrated management of organizational and technical changes was introduced by Gerbec (2017). Following the concept, an integrated MOC model shall consider the issues of technical/technological changes, the complexity of impacts or risk and how the change influences all levels of employee in an organization. Even though its implementation would drive a major improvement in process plant safety, lack of a systematic technique for easy adoption of this standard had delayed its application in plant. Therefore, this study presents an integrated MOC risk analysis system focusing on temporary and emergency cases in order to minimize the limitation in time prediction, prioritization of risk, record logging and storage into a more convenient yet less burdensome way.

METHODS

Figure 1 shows the overall flow of this research study. MOC Framework in this study is an extension of the Gerbec (2017) framework and risk assessment research. Following the concept of Gerbec (2017) model, an integrated MOC model should consider the issues of technical/technological changes, the complexity of impacts or risk and how the change influences all levels of employee in an organization (Gerbec, 2017). Data and

information collection on temporary and emergency change are performed by visiting two highly hazardous plants. Issues and current practice adopted in managing temporary and emergency changes are gathered from the above literature reviews, and through sharing session with the safety practitioners of the selected plants. An integrated system in managing both changes is needed which considers all issues identified through the data collection process.

On the other hand, another purpose of this study is to prevent ignorance or complacency towards risk behind short term changes. An integrated yet time-saving risk analysis is relatively critical in managing both types of changes. Improvement and modification are made on the proposed risk assessment checklist where risk rating is added into the adopted risk assessment checklist to highlight the risk prioritization and decision making.

Managing and updating of information manually are burdensome and challenging in the current technological era (Bakar et al., 2017). There is a need to implement technological aid to overcome the current MOC weakness in terms of workload and efficiency on information management. A well-developed and integrated management system would help in the data inventory and tracking of important information. Microsoft Access software was utilized to develop a MOC management process to achieve the objective of improving information management.

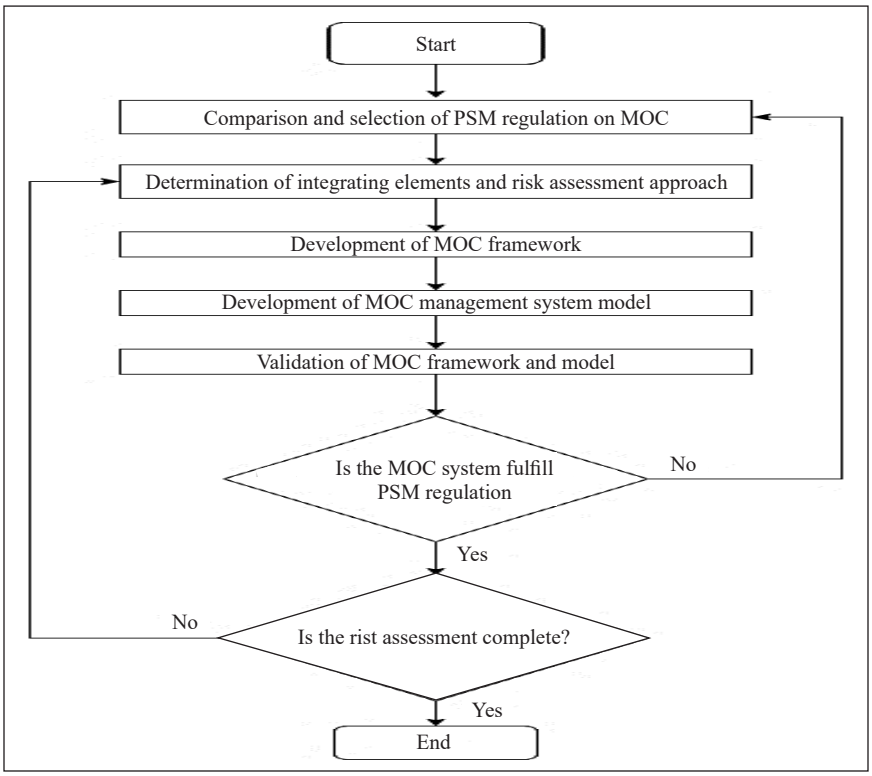


Figure 1. Overall process flow

Developed framework and MOCMS model were pilots tested at two plants in Malaysia. This pilot test was conducted to ensure the feasibility and efficiency of the developed result in real-life practice. This section displayed the functionality of the model in the real MOC case in the industry. Developed results and software were piloted on three MOC cases. Model performance efficiency survey was conducted involving focus group to obtain feedback and suggestion on the model.

Determination of Standard, Integrating Elements and Development of Framework

Process Safety Management (PSM) standard 29 CFR 1910.119 was referred as the basis of MOC framework development and to meet all the requirements as stated in the regulation. Critical elements and assessment which should be covered under MOC were studied through the literature review and standards. The risk assessment checklist by Gerbec (2017) had been embedded throughout the framework. The developed method consisted of two major nature of change; temporary and emergency. The Other five aspects that were covered under MOC were included for an efficient approach; technical basis for the proposed change; impact on safety and health brought by the change; modification to the operating procedure; necessary time period for the change; authorization requirements for the proposed change.

Computer Database Prototype System

The implementation of this technique was assisted by a computer database system in managing and communication the MOC cases. MOC management system (MOCMS) was developed to demonstrate the proposed framework using Microsoft Office Access and Excel environment. The system had been designed to allow for capturing documented data at specific evidence location either in the paper form within files, in computer databases or using a computer-aided design system.

Validation via Case Studies

The developed system was tested at the selected unit of process plants in Malaysia. A total of three MOC cases had been conducted to see the feasibility of the system in real-life practice.

RESULTS AND DISCUSSION

The Framework of Temporary, Urgent and Emergency MOCs

Temporary, urgent and emergency MOC frameworks developed in this study are shown in Figure 2, Figure 3 and Figure 4 respectively. Both changes were developed with similar action items but differed in terms of work flowchart due to time constraint in both natures

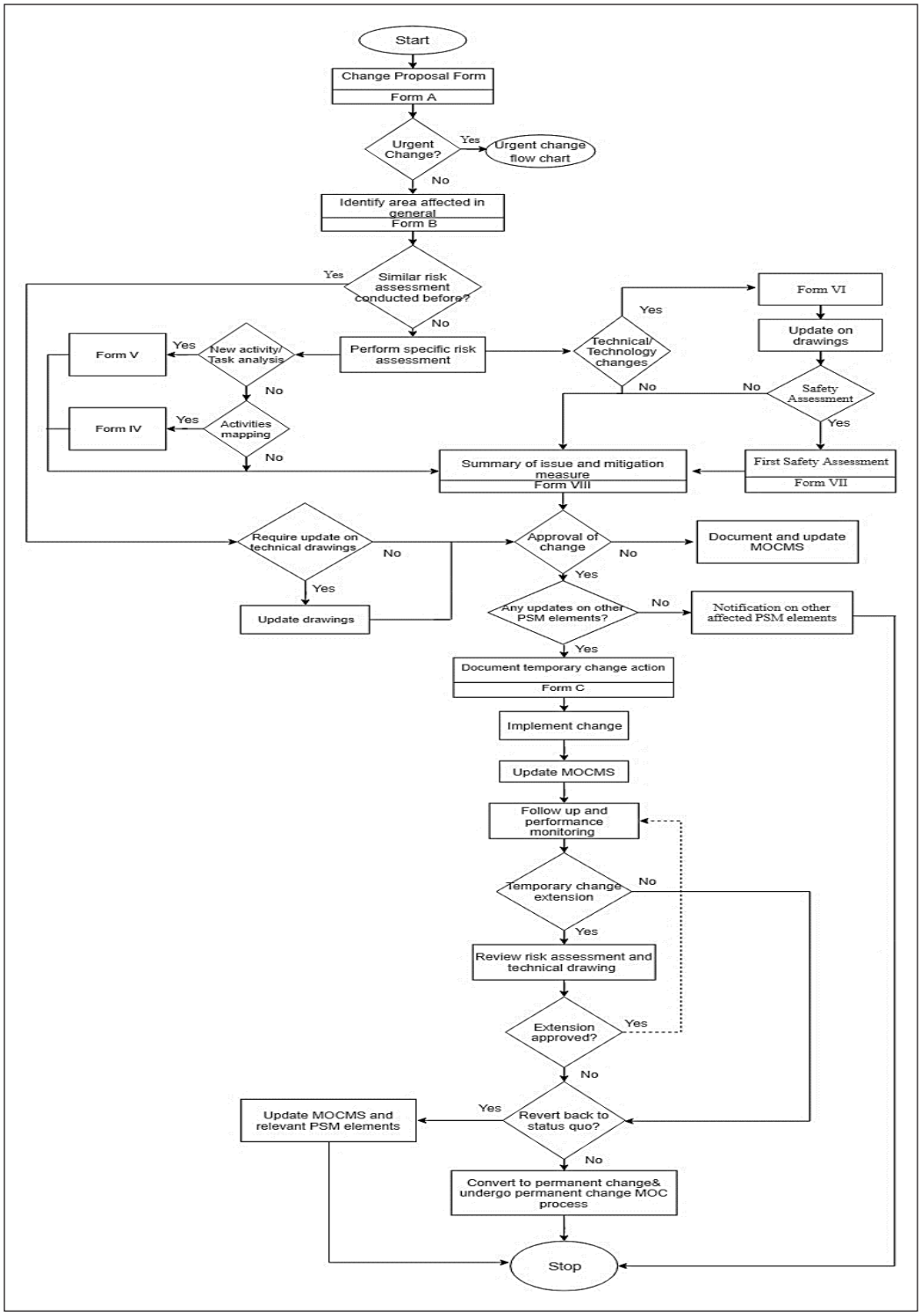


Figure 2. Temporary change framework

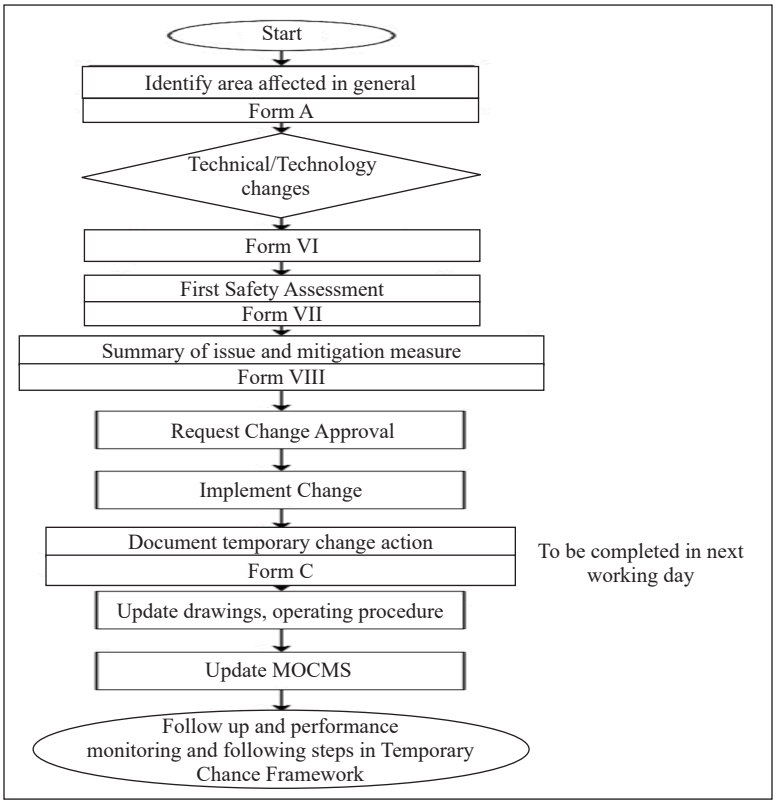


Figure 3. Urgent change framework

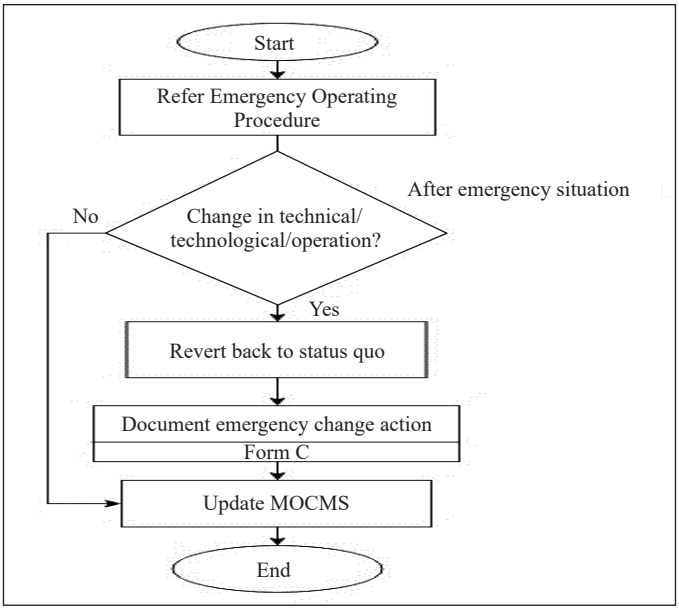


Figure 4. Emergency change framework

of change. Under temporary changes, there is a common temporary change and urgent change which shall be implemented within days or in a day. Besides, the emergency is different from the urgent change where urgent change may be implemented for a period of time whereas emergency change will only be required to perform during the emergency to prevent further destruction and devastating consequences.

Temporary Change. Temporary change framework (Figure 2) begins with identifying whether the proposed change is an urgent or normal temporary change. Changes which are planned to be implemented for 3 months and below can be considered as temporary changes. The urgent change can proceed to urgent change framework which is discussed in the next section. Non-urgent change undergoes general risk assessment checklist to identify the areas affected by the proposed, e.g. organizational or technical and technological aspect. Change that affects the organizational context in temporary change is proposed to perform simple task analysis and activities mapping between new and old job task whereas technical context comes with technological area risk assessment checklist. It will then proceed to specific risk assessment for the affected area. Every area affected by the change comes along with a proposed risk assessment checklist. Upon completion of the risk assessment, summary of risk and mitigation measure is be completed to highlight the risk prioritization and change approval. The implemented change will then update other related PSM elements including process safety information, mechanical integrity, operating procedures and so on.

Next, documentation comes in place where all forms and risk assessment checklist are stored in MOCMS. Follow up and performance monitoring on the implemented change is compulsory to be conducted throughout the implementation period. Follow up schedule can be decided based on the period of temporary change. In the case of the temporary change extension request, risk assessment and technical drawing will be a major consideration in this context. Approved extension of change is followed up to the validity of extension. Conversion of change back to the status quo will again update the MOCMS and relevant PSM elements. Any change approved to be converted to the permanent change will undergo permanent MOC process.

Urgent Change. Urgent change is one of the temporary changes which possess time restriction in planning and preparation work. Any proposed change which can be implemented within one to two days can be considered as an urgent change. There is a higher tendency which leads to neglection of MOC due to the urgent nature of the proposed change. In the developed framework, it is a simplified process of normal temporary change but possesses a similar compulsory risk analysis process as shown in Figure 3. It is proposed to overcome the time constraint by limiting the risk analysis to be completed within a day by using the proposed risk analysis checklist and forms by Gerbec (2017). Information

inventory and update of any related documentation can be performed the next working day after changes have been implemented.

Emergency Change. Emergency Change is an essential step of response in an emergency especially in the case of life saving, prevent further damage to the environment, property and process line. In an emergency, the emergency operating procedure will be the priority in response. In the developed framework as shown in Figure 4, changes made during the emergency are recorded for future review which can help in decision making and improvement in terms of emergency change procedure and emergency response procedure. Documentation framework in emergency change repeats the temporary change framework (Figure 2). Any changes during an emergency will revert to the status quo to resume operation after the emergency. In this case, the status quo can be the original setting or process according to the design specification. User will fill only Form C, as a summary of change action taken during an emergency.

Risk Assessment

Risk assessment checklist and related MOC forms were adopted from the work of Gerbec (2017) with a new improvement on his work to fit into this study. Improvised risk assessment checklist on technical and technological changes covered on the process, process conditions, inspections and maintenance as well as technical documentation aspects. The improvised risk assessment proposed on additional PHA risk rating to aid in risk prioritization and decision making (Galante et al., 2014). The concept of this risk assessment checklist is proposed to be a quick alternative of complete risk assessment for short term and emergency changes when other hazard analysis and risk assessment such as Hazard and Operability Study (HAZOP), Hazard Identification Studies (HAZID) require a large amount of time and group of expertise for the brainstorming session.

MOC Management System (MOCMS)

MOC Management System (MOCMS) comprises one dashboard, a data inventory form, nine tables, three queries and nine reports. This database is aimed at increasing the control over data inventory and tracking of information. It acts as active guidance merged with MOC framework throughout overall MOC process where the user may access all related forms and risk assessment checklist stored in the system in the early stage of change proposal and risk assessment. The system established is able to store all the vital information in MOC by storing it separately according to the type of risk assessment followed by a general MOC case and summary table storage. Next, MOCMS is acting as a data inventory system where the user may store all information and risk assessment checklist related to the change on one specific form. Meanwhile, in the later stage of the

framework, MOCMS will function as tracking tools to follow up and evaluation on change extension steps on open temporary MOC cases.

Case Study

To demonstrate the developed concept, three case studies had been conducted at the selected unit of the real plant. Since the plant is handling a flammable gas at a high pressure condition, it is compulsory by management that the unit is subjected to MOC program. Referring to Figure 5, end users may access data entry interface from the dashboard. This interface is designed for data input for all types of risk assessment and general information of MOC cases, summary and follow up action of the specific case.

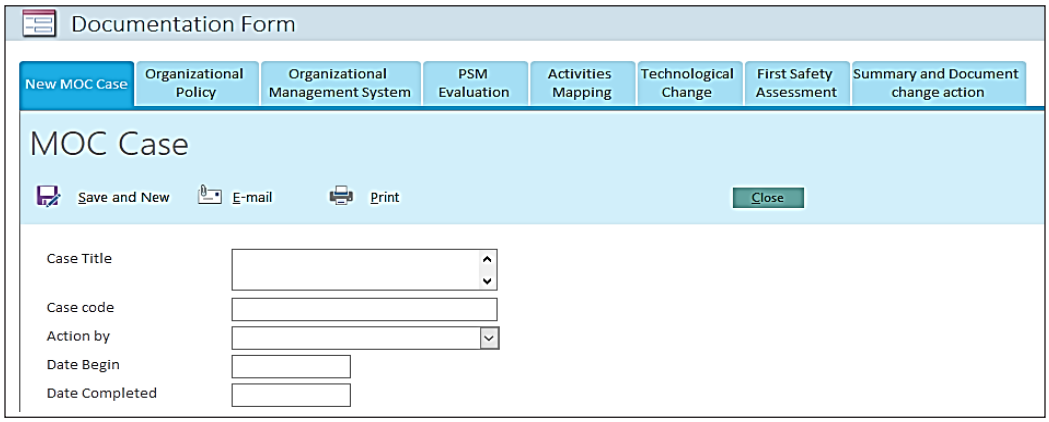


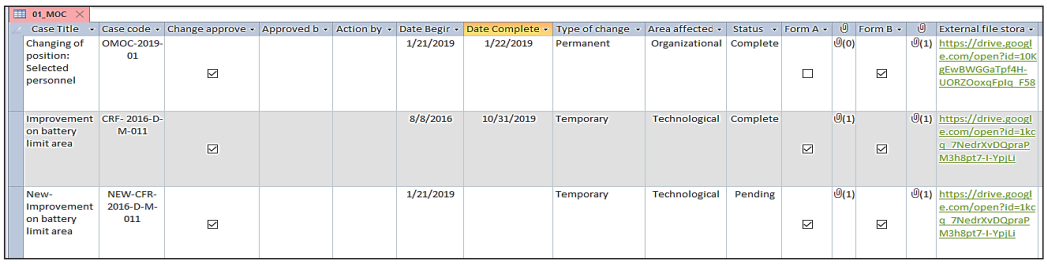
Figure 5. Documentation form interface in MOCMS

All data input will be interlinked to the MOC case information inserted from the first tab as shown in Figure 6. The interface of overall MOC cases in the system also designed to store data related to case code, the responsible person on approval and execution, date begin and due date, as well as storage of related documentation. There are several features designed to minimize the identified current issue in MOC. Time motion-based study is minimized by allocating time begun and time completed for every risk assessment. This feature aims to help in recording the period required to perform every risk assessment which can be used as a reference to predict the overall time required from the change proposal to approval. This is believed to be significant in solving the current issue of time constraint in MOC (Koivupalo et al., 2015). Furthermore, a feature which addresses the type of change, whether is permanent, temporary or emergency, would help end users to easily track on the previous type of change cases and related risk assessment conducted. Temporary cases may often be the loop of an organization in accident occurrence, as risk assessment are often simplified or merely absent due to the implementation period. Therefore, this

feature is convenient for end users in tracking back similar temporary cases and related risk assessment. Apart from that, there is another additional feature which enables the user to track the open task of MOC which is yet to meet to due date established. There is a status input which enables the MOC team to select whether the task is "Completed", "Pending" or "Incomplete". In addition, an open task query is designed to track on MOC cases which hold on the status of "Pending" or "Incomplete".

Apart from that, the technical and technological risk analysis checklist had been used on one of the existing temporary change cases during plant turnaround period, as shown in Figure 7. It shows that the risk assessment checklist is able to cover related items in the technical and technological area. The document is linked to the technical risk assessment interface on pilot test case is shown in Figure 8. This interface has the items of "Time begin" and "Time completed". This feature is made available in all risk assessment interface which aims to record the period required for every single risk assessment. This is believed to improve the prediction on time required for a complete MOC cycle and eventually helps to overcome the practice of time-motion based study in a previous MOC approach.

Next, Figure 9 shows the filled organizational change risk assessment checklist which was conducted on the changing of job position of selected personnel. Activities mapping risk analysis was conducted to analyze the hidden risk of the changing of work nature and job position. The result of activities mapping risk analysis of the specific organizational change. Based on case studies activities mapping aids in predicting any newly arose safety



01_MOC

Case Title	Case code	Change approve	Approved b	Action by	Date Begir	Date Complete	Type of change	Area affected	Status	Form A		Form B		External file stora
Changing of position: Selected personnel	OMOC-2019-01	☑			1/21/2019	1/22/2019	Permanent	Organizational	Complete	☐	(0)	☑	(1)	https://drive.google.com/open?id=10KgEwBWGGaTpf4H-UORZOoxqFplq_F58
Improvement on battery limit area	CRF- 2016-D-M-011	☑			8/8/2016	10/31/2019	Temporary	Technological	Complete	☑	(1)	☑	(1)	https://drive.google.com/open?id=1kcq_7NedrXvDQpraPM3h8pt7-I-YpiLi
New-Improvement on battery limit area	NEW-CFR-2016-D-M-011	☑			1/21/2019		Temporary	Technological	Pending	☑	(1)	☑	(1)	https://drive.google.com/open?id=1kcq_7NedrXvDQpraPM3h8pt7-I-YpiLi

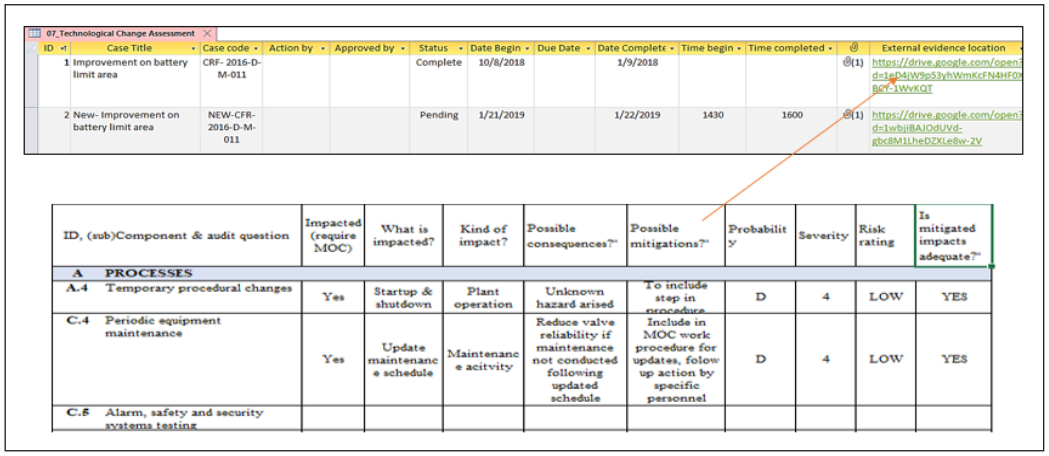
Figure 6. Overall MOC case interface on pilot test case

ID, (sub)Component & audit question	Impacted (require MOC)	What is impacted?	Kind of impact?	Possible consequences?*	Possible mitigations?*	Probability	Severity	Risk rating	Is mitigated impacts adequate?*
A PROCESSES									
A.4 Temporary procedural changes	Yes	Startup & shutdown	Plant operation	Unknown hazard arised	To include step in procedure	D	4	LOW	YES
C.4 Periodic equipment maintenance	Yes	Update maintenance schedule	Maintenance acitvity	Reduce valve reliability if maintenance not conducted following updated schedule	Include in MOC work procedure for updates, folow up action by specific personnel	D	4	LOW	YES
C.5 Alarm, safety and security systems testing									

Figure 7. Technical and technological change risk assessment checklist on pilot study

and health hazards, in addition of workload in new job task, evaluation of the adequacy of control measures and so on.

Figure 10 shows one of the queries developed in MOCMS which helps to track the list of temporary MOC cases. As shown in Figure 10, the query is designed to track temporary



07_Technological Change Assessment

ID	Case Title	Case code	Action by	Approved by	Status	Date Begin	Due Date	Date Complete	Time begin	Time completed	External evidence location
1	Improvement on battery limit area	CRF- 2016-D-M-011			Complete	10/8/2018		1/9/2018			(1) https://drive.google.com/open?id=1eD4jW9p53yhWmKcFN4HF0XBcY-1WvKQT
2	New- Improvement on battery limit area	NEW-CFR-2016-D-M-011			Pending	1/21/2019		1/22/2019	1430	1600	(1) https://drive.google.com/open?id=1wbjiBAJOdUVd-gbc8M1LheDZXLe8w-2V

ID, (sub)Component & audit question	Impacted (require MOC)	What is impacted?	Kind of impact?	Possible consequences?*	Possible mitigations?*	Probability	Severity	Risk rating	Is mitigated impacts adequate?*
A PROCESSES									
A.4 Temporary procedural changes	Yes	Startup & shutdown	Plant operation	Unknown hazard arised	To include step in procedure	D	4	LOW	YES
C.4 Periodic equipment maintenance	Yes	Update maintenance schedule	Maintenance acitvity	Reduce valve reliability if maintenance not conducted following updated schedule	Include in MOC work procedure for updates, folow up action by specific personnel	D	4	LOW	YES
C.5 Alarm, safety and security systems testing									

Figure 8. Technological risk assessment interface on pilot test case

	OLD ROLE ACTIVITIES											NEW ROLE ACTIVITIES								COMPARISON [b]		
				Involves [a]								Any new role issues?										
No	Appointed activities	Can it be eliminated?	Req. hours per week	Response to deviations	Assuring plant integrity	Assuring plant availability	Managing HSE procedures	Manages essential knowledge and expertise	Subject of change?	Significant risk?		Appointed activities	Req. hours per week	Significant HSE hazards?	High workload, fatigue?	Competence issues?	Communication issues?	Team work issues?	Motivation issues?	Old role control measures that were applied?	Additional measures needed, or any comments?	Will controls be adequate?
1	Deliver training program	No	15	Med	Med	High	Med	High	Med	Med		Management of shift, personnel, operation schedule	25	NA	No	Compatible education background but lack of related work experiences	No	No	No	Management training provided upon change of job position		Yes
2	Develop module	No	40	Low	Med	Low	Low	High	Low	Low		Taking sample for quality checking	10	Involves with process equipment, chemicals	No	No	No	No	No	Onsite chemical handling training		Yes
3	Schedule training program	No	4	Med	Low	Low	Low	Low	Low	Low		Participate in plant shutdown & startup	30	Involves with process equipment, chemicals	Maybe	No	No	No	No	Onsite chemical handling training		Yes
4	Evaluate training effectiveness	No	5	Low	Low	Low	Low	Low	Low	Low												

Figure 9. Activities mapping of pilot test organizational change case

Temporary MOC case

Type of change	Case Title	Case code	Date Begin	Date Completed	Action by	Area affected
Temporary	New- Improvement on battery limit area	NEW-CFR-2016-D-M-011	1/21/2019			Technological
Temporary	Improvement on battery limit area	CRF- 2016-D-M-011	8/8/2016	10/31/2019		Technological

Figure 10. Temporary change query in MOC

MOC case which displays all the vital information of temporary MOC cases with "Due date" and "Remarks". This query helps end user to easily track on the temporary case which will meet the due date. This is to improve the management of overdue temporary change. There are two queries designed to track on the open task and emergency change cases.

CONCLUSION

Three frameworks were established addressing common temporary change, urgent change and emergency change with respective critical action items and risk assessment. A MOCMS is established which stores all related risk assessment forms, change proposal, which also acts as a storage database for related documents. Pilot tests had been conducted to validate the framework and management system developed to determine the reliability and applicability in the real life operation process. It can be concluded that this system is able to ease the burden of documentation and yet proposes a new approach in MOC management. Tracking of open MOC task in the temporary and emergency case is additional features in the system. Time begin and completed field in the system is established to enhance the time prediction in performing every risk assessment and period required for a whole MOC process

In a nutshell, this study introduces a system to improve risk analysis and tracking of open MOC cases especially towards temporary and emergency changes. The framework developed in this study is aligned with the international standard on all the important criteria to be covered in a MOC process. Implementation of this system can serve as a database, guidelines and tracking tool in MOC.

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