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Review and Comparison of Confined Space Risk Assessment Tools Practised by Industry Code of Practice for Safe Working in Confined Space of Malaysia, 2010 (ICOP 2010)

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ABSTRACT

The aim of this paper is to identify the gaps of confined space risk assessment tools practised by Industry Code of Practice for Safe Working in Confined Space in Malaysia (ICOP 2010) comparing with the requirements of International Standard of Risk Management-Risk Assessment Technique (ISO 31010). There are 5 parts of Risk Assessment Element under the ICOP 2010, namely Part 1: The work to be undertaken, Part 2: The range of possible methods which can be used, Part 3: The present hazards, Part 4: Details of the actual method to be used for the particular work and Part 5: Procedure for rescue and emergency services will be analysed to identify the gaps. The list of risk assessment tools based on selected Journals including Checklist, Risk Scale, Risk Calculation, Ishikawa 5 Steps, Risk Estimation, Flexible Risk Assessment, Bowtie Risk Assessment, Hybrid Risk Assessment, Three Steps Construction Job Analysis and Risk Assessment Model will be mapped as a proposed Risk Assessment tools for ICOP 2010. The final outcomes of the review will help to improvise the existing Risk Assessment under the ICOP 2010 to be more operationally effective and can help to reduce the numbers of confined space accidents in Malaysia.

Keywords:
Confined Space, Risk Assessment Tools, ISO 31010, ICOP 2010, Fatality Accident

1. Introduction

Nowadays, industries in Malaysia are experiencing drastic growth due to increasing demand from foreign investors as well as local investors. It is a good sign from economic perspective but occupational safety and health issues especially for activities carried out in confined space should not be compromised. Working in confined space poses various types of hazards such as chemical, physical and biological hazards [2]. The higher numbers of industries mean the more types of activities need to be carried out such as maintenance, repairing and constructing [16]. Confined space is defined as “an enclosed or partially enclosed space that is at atmospheric pressure during occupancy and is not intended or designed as a place of work and is liable at any time to have an atmosphere which contains potentially harmful levels of contaminants, has an oxygen deficiency or excess, causes engulfment and has restricted means for entry and exit” [4].

Since the establishment of the first Confined Space Guidelines in 1998 until the recent ICOP 2010, the incidents related to confined space are still occurring where the report revealed that most of the victims of these incidents resulted in fatality. This sends an important message to the authority

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that there are some gaps needed to be closed in the current system. Figure 1 depicts the Confined Space Accident Statistics in Malaysia from 2009 to 2019.

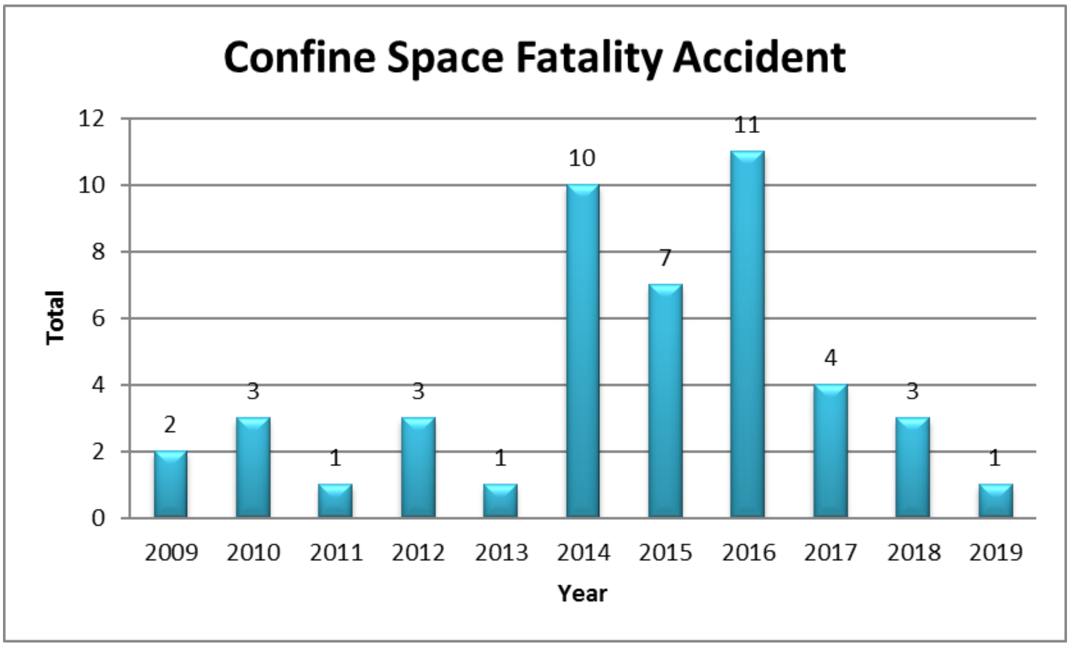

Fig. 1. Confined Space Accident Statistics

Based on the investigation conducted by Department Occupational Safety & Health (DOSH), it was found that the contributing factors are lack of awareness or competency, absence of risk assessment documents and absence of Safe Work Procedure. It is clear that employer of the organisation should play their roles in ensuring safe working environment in confined space by providing competency training to all workers, acquiring safety equipment and atmospheric measuring devices [24]. Furthermore, another contributing factor is the risk assessment method under the ICOP 2010 prior to entering a confined space is too generic which resulted in overlooking of important elements to be assessed such as configuration of confined space, specific hazards and its risk, tools and equipment to be used and numbers of occupants which may affect the entire rescue plan [6 - 8).

In the process of risk assessment, the main elements of risk assessment to be prioritized are risk identification, risk analysis and risk evaluation. Risk treatment is an additional process which is required to be carried out to ensure that the action plan is appropriate [13]. In respect of hazardous confined space, the assessment of risk is vital and the process required is specific to the type of working environment. Additionally, reviewing of the effectiveness of risk assessment is highly recommended especially when there are high numbers of incident related to a particular working environment. One approach that could be used is by referring to the actual incident scenario where the information gathered and the incident environment is genuine. A Checklist, Risk Scale, Risk Calculation and Ishikawa 5 Steps Risk Assessment are the risk assessment tools which were studied and developed by referring to the confined space incident scenario [6]. Every risk assessment tool was properly analysed and critically reviewed on its suitability to be implemented and opportunity to enhance. According to Moatari-Kazerouni *et al*., [1], the development of risk estimation tools were resulted from the manufacturing process which involves machinery. It focused on the risk analysis process where the new method in determining risk level is proposed first before obtaining the risk value and percentage of exposure to machinery. The Flexible Risk Assessment (FRA) proposed by Reinhold *et al*., [15] is to overcome safety issues in Small Medium industries. It is a simple risk assessment tool of which the results of the assessment are easy to interpret based on its risk contributor. The risk evaluation ranges from High Risk consisting of Intolerable, Inadmissible and Unjustified Risk to Low Risk consisting of Justified Risk and Tolerable Risk. Bow-tie risk assessment tool for falling object was proposed by Aneziris *et al*. [19]. Bow-tie analysis is divided into two parts, namely Threat (Preventive Measures) and Consequences (Mitigation Measures) and it covers the entire process of risk assessment. This analysis is widely used in industries either for conducting risk assessment or investigation of accident. The Hybrid Risk Assessment Process (HRAP) proposed by Marhavilas *et al*. [21] is a comprehensive risk assessment tool where it is a combination of qualitative-quantitative assessment method. The phases of HRAP consist of Identification of hazard source, Risk consideration / Estimation, Risk Evaluation and Risk assessment. The Construction Job Safety Analysis (CJSA) proposed by Rozenfeld *et al*. [18] is another method of risk assessment used widely in the industries especially in the construction industry. The approach of CJSA is straight forward where it basically focuses on the specific job activities and the identification of hazards is through the sequence of jobs. The Risk Assessment Model (RAM) proposed by Fung *et al*. [14] is commonly adopted by the construction industry. All the input data related to incidents are collected and analysed in order to obtain severity rate and subsequently it can be used to identify the most hazardous work trade.

2. Methodology

In identifying gaps under the ICOP 2010, the review is carried out by describing the risk assessment process under the ISO 31010 and risk assessment element under the ICOP 2010. Thereafter, the mapping process between both of the methods by way of matrix table will be conducted to identify which particular phase of ISO 31010 is corresponding to ICOP 2010. It will be then followed by mapping the list of risk assessment tools proposed by the selected Journals to recognize the risk assessment tools of each risk assessment process under the ISO 31010 in the matrix table.

Table 1
Phases of Risk Assessment ISO 31010

Phase	Risk Assessment Process	Description
RI	Risk Identification	Risk identification is the process of finding, recognizing and recording risk where the main objective is to identify what might happen or what situations might affect the overall system in an organization.
RA	Risk Analysis	Risk analysis is about developing an understanding of risk. It provides input to risk assessment and decisions as to whether risks need to be treated and the most appropriate treatments, strategies and methods.
RE	Risk Evaluation	Risk evaluation involves comparing estimated levels of risk with the defined risk criteria in order to determine the level and type of risk. Risk evaluation uses the understanding of risk obtained during risk analysis to decide on the future actions to be taken.
RT	Risk Treatment	Risk treatment is about the types of actions need to be taken based on the level of risk which has been identified through the risk analysis process

The phases of risk assessment process under the ISO 31010 are described in Table 1 below and every phase of risk assessment process is marked as RI, RA, RE and RT accordingly. The elements of risk assessment tools under the ICOP 2010 are described in Table 2 below. Every process of risk assessment is marked as P1, P2, P3, P3 and P5 accordingly.

Table 2
Risk Assessment ICOP 2010

ITEM	RISK ASSESSMENT ELEMENT	DESCRIPTION
P1	The work to be undertaken	It explains on the actual works to be carried out in confined space e.g. how the welding works are to be conducted.
P2	The range of possible methods which can be used	It explains on how works can be carried out e.g. to be carried outside of confined space, types of ventilation such as force air ventilation, using supplied-air respiratory devices, preventing recirculation of exhaust gases and ensuring continuous gas monitoring.
P3	The present hazards	This section provides estimation of risk level starting from low (1) to high (5). The hazards to be assessed are chemical and physical forms.
P4	Details of the actual method to be used for the particular work	The details of work need to be described in specific manner such as how to do purging, ventilation, blanking, necessary action to be taken when gas alarms is alerted, competent gas tester and an option to wear supplied-air respiratory devices.
P5	Procedure for rescue and emergency services	It describes the types of rescue devices to be used for access and rescue such as tripod, safety harness, appropriate PPE, communication method and competent rescue personnel.

The proposed Risk Assessment tools (RA Tools) based on selected Journals are tabulated in Table 3 below to identify which RA Tool matches with each phases of risk assessment process of ISO 31010.

Table 3
Mapping between selected Risk Assessment tools and ISO 31010

RA Tools	ISO 31010			
	RI	RA	RE	RT
RA1 - Check list	X			
RA2 - Risk Scale			X	
RA3 - Risk Calculation		X		
RA4 - Ishikawa	X	X	X	X
RA5 - Risk Estimation				
RA6 - Flexible Risk Assessment	X		X	X
RA7 - Bow-tie Analysis	X			X
RA8 - Proportional Risk Assessment (Hybrid)	X	X	X	X
RA9 - Three step CJSA	X			X
RA10 - Risk Assessment Model	X	X	X	X

Based on Table 3 above, it revealed that some RA tools did not fully satisfy all requirements of ISO 31010, namely Checklist, Risk Scale, Risk Calculation, Risk Estimation, Bow-tie and Three Step CJSA. However, three of the RA Tools were observed to fulfill all requirements of ISO 31010, namely Proportional Risk Assessment, Ishikawa five step and Risk Assessment model.The matrix table in Table 4 below shows the mapping between the practices of risk assessment process under ISO 31010 and ICOP 2010 in order to identify the gaps.

Table 4
Mapping between ICOP 2010 and ISO 31010

ICOP 2010	ISO 31010			
	RI	RA	RE	RT
P1	X			
P2	X			
P3		X	X	
P4				X
P5	X			

Based on Table 4 above, every stage of risk assessment process under ICOP 2010 is corresponding to different phases of risk assessment process under ISO 31010. Based on the mapping results, P1 and P2 were categorized as RI, P3 was categorized as RA and RE while P4 and P5 were categorized as RT and RI respectively

3. Results

The process of identifying the practices of risk assessment process under the ICOP 2010 and its compliance with the ISO 31010 was conducted. In addition, the selected RA Tools based on the selected journals were observed of its contribution towards ISO 31010. Based on the mapping conducted, the gaps of risk assessment process under the ICOP 2010 were identified by comparing with ISO 31010 and the RA tools will be proposed in order to close the gaps identified. With reference to Table 3 and Table 4 above, the results depicted in Table 5 below are the fitment of RA Tools based on the selected Journals into the risk assessment process under the ICOP 2010 in accordance with the requirements of ISO 31010.

Table 5
RA Tools Fitment to ICOP 2010

ICOP 2010	ISO 31010			
	RI	RA	RE	RT
P1	RA1,RA4, RA6,RA7,RA8, RA9,RA10			
P2	RA1,RA4, RA6,RA7,RA8, RA9,RA10			
P3		RA3,RA4, RA8,RA10	RA2,RA4,RA6, RA8,RA10	
P4				RA4,RA6, RA7,RA8, RA9,RA10
P5	RA1,RA4, RA6,RA7,RA8, RA9,RA10			

Based on the results shown in Table 5 above, every phase of risk assessment (P1 to P5) under the ICOP 2010 was matched with several RA tools based on the selected Journals. Through this mapping exercise, the gaps of risk assessment process under the ICOP 2010 can be improved and the suitability of each of the RA tools will be discussed in detail below.

To improvise the gaps of [P1: The work to be undertaken], [P2: The possible of work method which could be used] and [P5: Procedure for rescue and emergency services], seven RA tools for **Risk Identification (RI)** were proposed as follows:

- [RA1 = Checklist]: This method proposed to use checklist to prevent overlooking of important elements of hazard identification
- [RA4 = Ishikawa]: This method proposed to use mapping process on the works to be carried out, category of hazards and type of risk
- [RA6 = Flexible Risk Assessment]: This method proposed to use qualitative risk assessment approach in identifying hazards related to hazardous substances
- [RA7 = Bow-tie Analysis]: This method proposed to identify hazards pro-actively by predicting the threat that might cause an accident
- [RA8 = Proportional Risk Assessment]: This method proposed to use quantitative and qualitative approach by identifying hazards, its effect and severity of harm
- [RA9 = Three Step CJSA]: This method proposed hazard identification process according to specific job tasks
- [RA10 = Risk Assessment Model]: This method proposed hazard identification through site observation and inputs from previous incident

To improvise the gaps of [P3: The hazards present], six RA tools for **Risk Analysis (RA)** and **Risk Evaluation (RE)** were proposed as follows:

- [RA2 = Risk Scale]: This method proposed four levels of risk for Risk Evaluation process, namely extreme, high, moderate and low
- [RA3 = Risk Calculation]: This method proposed 4 X 4 matrices to determine likelihood and severity with descriptions for Risk Analysis process
- [RA4 = Ishikawa]: This method proposed five levels of severity and harm scale with risk matrices for Risk Analysis and Risk Evaluation process
- [RA6 = Flexible Risk Assessment]: This method proposed a qualitative approach in risk evaluation where high risk is classified as intolerable, inadmissible and unjustified risk whereas low risk is classified as justified and tolerable risk
- [RA8 = Proportional Risk assessment]: This method proposed evaluation of risk by computing likelihood, severity and frequency in order to determine the level of risk
- [RA10 = Risk Assessment Model]: This method proposed an effective way to compute rate of severity by dividing “Total Numbers of Workdays Lost” with “Total Manhours Worked” multiply by one million prior to evaluation of risk level

To improvise the gaps of [P4: Details of the actual method to be used for the particular work], six RA tools for **Risk Treatment (RT)** were proposed as follows:

- [RA4 = Ishikawa]: This method proposed a Risk Reduction Principles based on the result of risk evaluation such as elimination of risk at design stage, engineering approach, administrative and personnel protection
- [RA6 = Flexible Risk Assessment]: This method proposed actions to be taken for high risk level known as intolerable, inadmissible and unjustified

- [RA7 = Bow-tie Analysis]: This method proposed mitigation measures to be taken before consequences takes place
- [RA8 = Proportional Risk Assessment]: This method proposed five levels of urgency for actions to be taken based on the result of likelihood, severity and frequency calculation
- [RA9 = Three Step CJSA]: This method proposed control measures to be taken based on the hazards identified
- [RA10 = Risk Assessment Model]: This method proposed action plan to be taken based on the level of risk obtained from the rate of severity in order to identify the type of control measures for on-going tasks

4. Conclusions

Based on the results above, it shows that there is much room for improvement based on the review conducted on ICOP 2010 to identify the gaps of risk assessment process. The mapping exercise conducted by comparing ISO 31010 requirements with ICOP 2010 has shown the significant difference in each phase of risk assessment process. Additional inputs by the proposed RA Tools based on the selected Journals are relatively useful. Furthermore, further research needs to be conducted to study the suitability and practicality of the implementation of the proposed RA Tools under the ICOP 2010.

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References
[1] Moatari-Kazerouni, Afrooz, Yuvin Chinniah, and Bruno Agard. "A proposed occupational health and safety risk estimation tool for manufacturing systems." *International Journal of Production Research* 53, no. 15 (2015): 4459-4475.
[2] STOJKOVIĆ, ANA. "Occupational Safety In Hazardous Confined Space." *INŽENJERSTVO ZAŠTITE* (2013): 137.
[3] Pinto, Abel, Isabel L. Nunes, and Rita A. Ribeiro. "Occupational risk assessment in construction industry–Overview and reflection." *Safety science* 49, no. 5 (2011): 616-624.
[4] Department of Occupational Safety and Health, 2010. Industry Code of Practice for Safe Working in a Confined Space, Ministry of Human Resource, Malaysia
[5] Burlet-Vienney, Damien, Yuvin Chinniah, and Ali Bahloul. "The need for a comprehensive approach to managing confined space entry: summary of the literature and recommendations for next steps." *Journal of Occupational and Environmental Hygiene* 11, no. 8 (2014): 485-498.
[6] Burlet-Vienney, Damien, Yuvin Chinniah, Ali Bahloul, and Brigitte Roberge. "Design and application of a 5 step risk assessment tool for confined space entries." *Safety science* 80 (2015): 144-155.
[7] Burlet-Vienney, Damien, Yuvin Chinniah, Ali Bahloul, and Brigitte Roberge. "Risk analysis for confined space entries: Critical analysis of four tools applied to three risk scenarios." *Journal of occupational and environmental hygiene* 13, no. 6 (2016): D99-D108.
[8] Burlet-Vienney, Damien, Yuvin Chinniah, Ali Bahloul, and Brigitte Roberge. "Occupational safety during interventions in confined spaces." *Safety science* 79 (2015): 19-28.
[9] Government of Malaysia, 2018. Factories and Machinery Act, 1967 (Act 139)
[10] Government of Malaysia, 2011. Occupational Safety and Health Act, 1994 (Act 514)
[11] Health and Safety Executive, 2013. Safe Work in Confined Spaces
[12] International Organization for Standardization (ISO), 2009, Risk Management – Principles and Guideline (IEC/ISO 31000:2009). ISO, Geneva, Switzerland
[13] International Organization for Standardization (ISO), 2009. Risk Management – Risk Assessment Techniques (IEC/ISO31010:2009). ISO, Geneva, Switzerland

[14] Fung, Ivan WH, Vivian WY Tam, Tommy Y. Lo, and Lori LH Lu. "Developing a risk assessment model for construction safety." *International Journal of Project Management* 28, no. 6 (2010): 593-600.

[15] Reinhold, Karin, Marina Järvis, and Piia Tint. "Practical tool and procedure for workplace risk assessment: Evidence from SMEs in Estonia." *Safety science* 71 (2015): 282-291.

[16] Botti, Lucia, Emilio Ferrari, and Cristina Mora. "Automated entry technologies for confined space work activities: A survey." *Journal of occupational and environmental hygiene* 14, no. 4 (2017): 271-284.

[17] Wilson, Michael P., Heather N. Madison, and Stephen B. Healy. "Confined space emergency response: Assessing employer and fire department practices." *Journal of Occupational and Environmental Hygiene* 9, no. 2 (2012): 120-128.

[18] Rozenfeld, Ophir, Rafael Sacks, Yehiel Rosenfeld, and Hadassa Baum. "Construction job safety analysis." *Safety science* 48, no. 4 (2010): 491-498.

[19] Aneziris, O. N., I. A. Papazoglou, M. Mud, M. Damen, L. J. Bellamy, H. J. Manuel, and J. Oh. "Occupational risk quantification owing to falling objects." *Safety science* 69 (2014): 57-70.

[20] Wilson, Peg, and Qingsheng Wang. "Development of a protocol for determining confined space occupant load." *Process Safety Progress* 33, no. 2 (2014): 143-147.

[21] Marhavilas, P. K., D. E. Koulouriotis, and C. Mitrakas. "On the development of a new hybrid risk assessment process using occupational accidents' data: Application on the Greek Public Electric Power Provider." *Journal of loss prevention in the process industries* 24, no. 5 (2011): 671-687.

[22] Pereira, Steven P. "Gas Testing for Confined Space Entry." In *ASSE Professional Development Conference and Exposition*. American Society of Safety Engineers, 2012.

[23] Standards Australia, 2001. Safe Working in a Confined Space (AS/NZS 2865:2001). Standards Australia, Sydney

[24] Wilkinson, Antony, Kenneth Burns, Alan Simpson, Kirsty Walker, and Martin Hunter. "Improving the control of confined-space entry through the implementation of an operational standard and competence based training." In *International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production*. Society of Petroleum Engineers, 2012.