

CRITERIA FOR SAFETY AND HEALTH IN DESIGN: PERCEPTION OF INDUSTRIES IN MALAYSIA

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Abstract

Safety and health design is a risk managing technique widely used in many industries, such as manufacturing, construction, chemical, marine, and healthcare. This method is also considered a prevention measure through design. It can be used to design or redesign a process, product, or workplace, taking into account the safety and health of workers and people at the workplace. This paper identified and analyses the criteria for safety and health in design implementation using the factor analysis procedure. The research partners were 117 who involved in design and manufacture of the product such as machinery and workplace. The result showed that 25 has been identified as criteria for safety and health in design implementation. Ten criteria included in OSH Management component and the other 15 categorized as operational management.

Keywords: Safety and health in design, factor analysis, OSH management, operational management

1.0 Introduction

Safety in design was recognized by many countries as a factors to prevent accident such as Australia, United States and United Kingdom (Safe Work 2019). Work design that protects workers from risks to safety and health is also part of Occupational Safety and Health Act 1994 in Malaysia. It is stated under Section 20 and 21 of the laws that machinery and workplace designers and manufacturers are responsible to the safety and health of the workers (OSHA 1994). Safety in design or mainly known as prevention of accident through design was identified by scholars as a main factor to ensure safety and health at workplace (Toole & gambatese 2017, Che Ibrahim et al. 2019). There was a presumption that safe and healthy workplace design will contribute to prevention of accidents, injuries, illness and diseases. The responsibility to make safe product is during the design process (Caputo et al. 2013; Rajabalinadab 2019) by integrating the knowledge of safety into the process (Sadeghi et al. 2015). According to Leveson 2017, accident prevention features should be assimilated into the system design rather than modifying and improving the existing systems and adding new features to overcome hazardous events. Hazard should be eliminated and risk reduced in the early stages of design (Sadeghi et al. 2015). In managing and implementing the safety and health in design, there are factors need to be considered such as risk and operation management (Asmalia 2013; Goode et al 2016; Leveson 2017; Fu et al 2020). Therefore, this study focused on identifying and recognizing factors influence the safety and health in designing machineries and workplace. The objective of this paper is to identify the criteria for safety and health in the design to ensure safe and healthy workplace are prepared.

2.0 Literature Review

The U.S. Bureau of Labour Statistics (2019) reported that incidents involving contact with objects and equipment increased by 13% from 695 to 786, including a 39% increase in workers caught in running equipment or machinery, and a 17% increase in workers struck by falling objects or equipment. Somewhat similar situations were also reported previously in other industrialised countries such as the United States (Toole & Gambatese 2017; Australia (Safe Work 2019) and Singapore (Che Ibrahim et al. 2019).

Meanwhile, according to the Occupational Accidents Statistic in Malaysia, a total of 21,534 cases of occupational accident reported in 2021 decreased 34% from 2021 (DOSM 2022). The fatality rate ratio per 100,000 workers increased gradually from 4.21 in 2014 to 4.90 in 2017 but decreased to 2,00 in 2020. Meanwhile, the accident rate ratio per 1,000 workers was 2.81 in 2015, 2.93 in 2017 and declined to 1.43 in 2020 (DOSM 2022). Chart 1 show the number and rate of annual occupational injuries and fatal occupational injuries from 2012 to 2021. The declined figure from 2019 to 2021 maybe affected by the pandemic Covid-19. The most important thing to discussed is the reason why accident happened and how to prevent it from occurred. Statistic shows the total number of accident with the highest agent if accident was working environment (10,412), followed by means of transport and lifting equipment (3,129) and machines (2,222). Table 1 show the overall cause of accident in Malaysia in 2021.

Chart 1: Number and rate of annual occupational injuries and fatal occupational Injuries 2012-2021

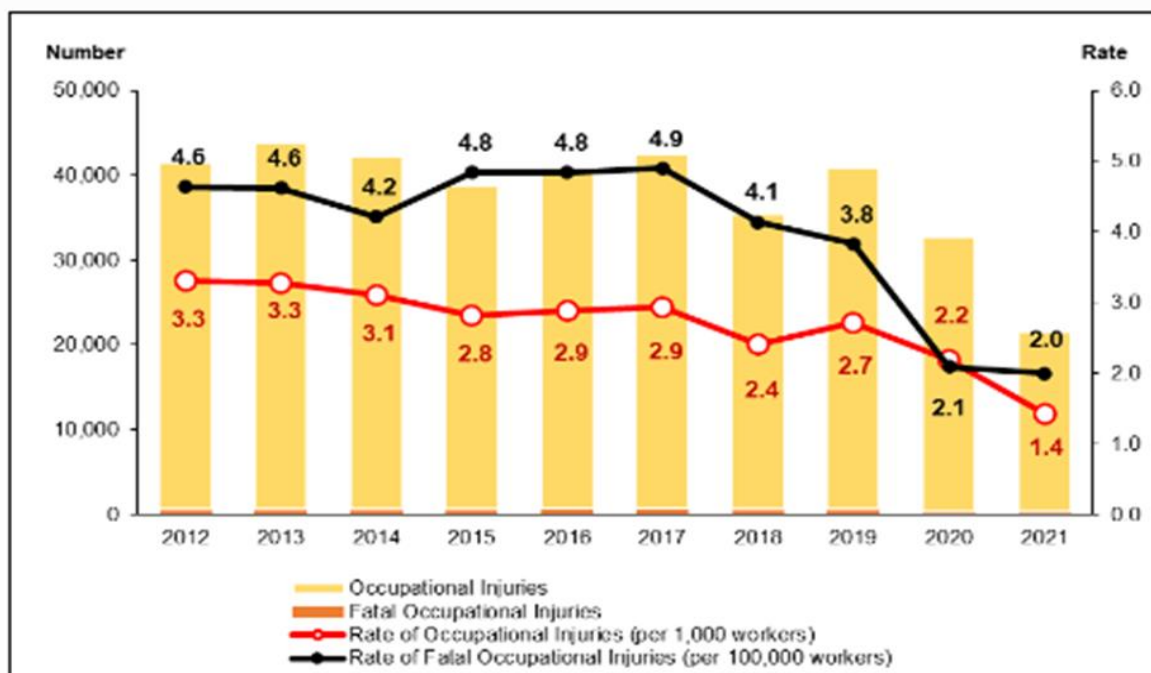


Table 1 Cause of occupational accident for 2021.

Agent of accident	Cause	Number
Agent of accident	1. Working environment	10,412
	2. Means of transport and lifting equipment	3,129
	3. Machines	2,222
	4. Agencies not classified for lack of sufficient data	2,035
	5. Tools, implements and appliances, except electric hand tools	1,791
	6. Other agencies, not elsewhere classified	1,035
	7. Materials, substances and radiations	567
	8. Other equipment	136
	9. Refrigerating installation, including electric motors	127
	10. Work from home	63
	11. Furnaces, ovens, kilns	17

Since the working environment, lifting equipment and machines showed the most number of accidents, there are a need to explore the causes of accident. Most of the organizations learnt to prevent future incidents by converting an incident experience into activities (Jacobsson et al. 2012). Several models in the literature describe this process of recognizing the causal factors and analysis of incident data will automatically lead to new knowledge of prevention strategies (Toole & Gambetese 2017). Based on the concept of prevention through design or in this study safety and health in design, further ownership of stakeholders towards safety and health at workplace need to address. Safety in design is a concept that has been practiced in several countries and has been applied to in different ways, such as

Safe Design in Australia, Prevention through Design in the US, Construction Design and Management (CDM) in the UK and (Che Ibrahim et al 2019). In implementing safety and health in design, designers, engineer and other stakeholders have a special responsibility to take into account as much as possible of the processes involved in the activities or life cycle of work including human factors, organisational issues and life-cycle management to eliminate or control hazards over life cycle of the project in construction (Gambatese et al. 2017; Che Ibrahim et al. 2019) and other product and workplace (Barker & Casey 2012; Ibo van de Poel & Zoë Robaey 2017; Fu et al 2020). While most of the study for safety in design focused on construction, there is a lack of research in designing safe product to be used at workplace (Rajabalinejad 2019).

Design of a safe product is responsibility for everyone involved in the product lifecycle. Removing all hazards is required to aim for safety and health. While eliminating the hazard is not truly possible, there are other approach to protect user such as substitution, engineering controls, administrative control and using personal protective equipment (NIOSH CDC 2022). Removing the hazards for protecting users can be done from early stage the design process. Rajabalinejad (2019) stated safety by design recognize the risky situations and overcome circumstances that can cause harm to human, environment or property if failed to work properly. Figure 1 show the distinction between design, hazard and risk whether the structure is working, safe functioning and use properly from the design stage. The designers or engineers and stakeholders can think of safety and health as a part of the best practices for design. (Rajabalinejad 2018).

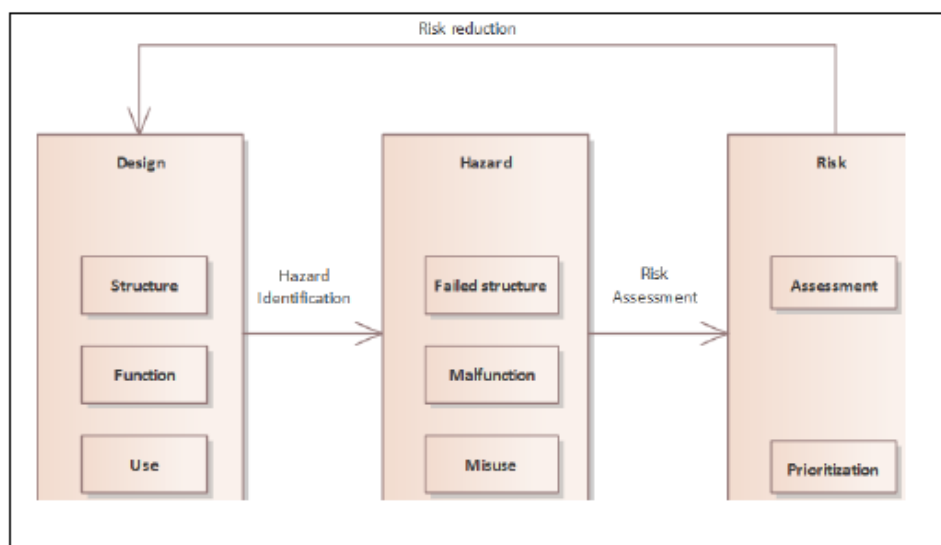


Figure 4: The process for safety by design (Source: Rajabalinejad 2019)

3. Research Methodology

The methodology used in the research is as showed in research framework in Table 2. The data from the literature review was compile to get the most significant research methodology for the study.

Table 2 Research framework.

Literature Review Research Methodology	Identification of factors that influence the safety and health design implementation
	Identification of research population and sample. Development of research questionnaires using LIKERT scales [8] Collecting data through questionnaires Data analysis using SPSS version 25 software
Data Analysis	Exploratory Factor Analysis– Analyzing the criteria for influence the implementation of safety and health design in order to find the most important criteria for safety and health design.

4. Demographics data

Population chosen in the research is the industries involved in designing, manufacturing, using the machineries and preparing the workplace to use. The respondents meet the criteria in the data collection (Etikan et al.2015). Demographic information of the respondents is as shown in Table 3.

Table 3 Socio demographic of the respondents

Demography	Category	Frequency	Percent (%)
Academic Qualification	Certificate	44	37.6
	Diploma	29	24.8
	Degree	33	28.2
	Master	8	6.8
	PhD	3	2.6
Profession	Architect	1	0.9
	Designer	2	1.7
	Engineer	22	18.8
	Construction Management	7	6.0
	Facility Management	8	6.8
	Project management	30	25.6
	Software Development	5	4.3
	OSH Professional	6	5.1
	Others	36	30.8
	Duration of service	1 - 5 years	43
6 - 10 years		22	18.8
11 - 15 years		18	15.4
16 - 20 years		14	12.0
21 - 25 years		10	8.5
	26 years and above	10	8.5

The respondent's education is ranging from certificate to PhD holder. The certificate holder represents most of the respondents (37.6%). Degree holder is the second higher (28.2%), followed by diploma holder 24.8% and master degree 6.8%. PhD holder is the smallest group of respondent (2.6). This finding represent various background of the respondents. The table also represent a wide group of profession including project management (25.6%), engineer (18.8%), facility management (6.8%), construction management (6.0%), OSH professional (5.1%), software development (4.3%) and architect (0.9%). Meanwhile other respondent not stated the profession is 30.8%. Although most of the respondent is not a designer itself, the study is considered valid since we are aim of the perceptions of all stakeholders in industries. Duration or services play the important factors since the experience of the respondents have expand the wide range of knowledge. More than 20 years' services consist of 17% of respondent and the most is 1 to 5 years' service (36.8%).

5. Analysis Criteria of Safety and Health in Design

A total of 25 items were identified and analysed using in SPSS to assess the importance of decision-making criteria to ensure safety and without risk to the health. While using the product designed. As shown in Table 4, the appropriateness of the data to factor analysis was assessed and listed (De Vaus 2002; Chua 2009b; Taherdoost et al. 2014). The results showed the correlation between load factors 1 and 2 are strong at 0.7. The factor analysis results were prepared according to the interests of the items under load factors labelled as occupational safety and health management (factor 1) and operational management components (factor 2).

Table 4 Factor analysis for criteria for safety and health in design

Criteria	Loading factor	
	1 OSH management	2 Operational management
User safety	0.879	
Risk control	0.876	
Worker health	0.866	
Risk assessment	0.851	
Worker safety	0.849	
Hazard identification	0.837	
Laws and guidance	0.774	
Ergonomic and human factor	0.727	
Regulator’s approval	0.682	
Client need	0.579	
Preservation of machinery		0.830
Manufacturing duration		0.775
Manufacturing method		0.749
Technology		0.733
Buildability		0.716
Material		0.702
Maintainability		0.692
Aesthetic value		0.677
Product lifecycle		0.671
Endurance		0.655
Cost		0.636
Quality		0.627
Procurement system		0.615
Interaction among person involve		0.584
Contract agreement		0.546

6. Discussion and recommendation

The analysis results on the industrial perception of implementation of safety and health in designing machinery and workplace showed. Table shows that there are the two major components with criteria to consider for implementation of safety and health namely OSH management and operational management. The observed values of the items contained in the two components were significantly identified. This indicates that both factors are important and need to be considered equally in designing. These findings are supported by previous studies that suggested OSH management should be integrated into the design process (Asmalia 2013; Leveson 2017; Safe Work 2019, Fu et al 2020). The main criteria of this analysis found the requirement to ensure the safety and health of workers in OSH management as the highest priority. Other important elements that need consideration including risk assessment and control, hazard identification. Other important criteria are laws and guidance, regulator’s approval, client need and ergonomic and human factor. This is most probably same as requirement of hazard identification, risk assessment and risk control introduced by scholars and the regulatory body (Caputo et al. 2013; Sadeghi et. al 2015, Leveson 2017, Rajabalinejad 2019).

The second invention is operational management factors that denote the importance of preserving machinery, timing, method and considering buildability in manufacturing technology, materials used, and maintainability As stated by Rajabalinejad (2019) these element are the important factors need to consider during designing the product. Additionally, the need to maintain the aesthetic values, the life cycle of machinery, durability, cost of manufacture the machinery, equipment quality, system cost, interaction with members of the manufacturing and approval of contracts are elements commonly used before designing the process and choosing the machinery to be used (Sadeghi et al. 2016; Rajabalinejad 2019, Leveson 2017). This study revealed sustainability of machinery and interaction with

the members involved in the operational activities are the new elements in the list of safe design criteria that need to be addressed. This new elements of safety in design will give huge impact to the industries where cost of operation is the most important matter.

8. Conclusions

Based on previous studies investigating how industries addressed safety matters upon an accident, this paper examined the factors that contribute to safety and health design implementation as a factor to prevent accident. As expected, user safety and worker health are among the most important elements in safety and health design. Other important elements are hazard identification, risk assessment and risk control including ergonomic and human factor. Meanwhile, laws and guidance, regulators' approval, and clients' needs or expectations are the elements that should be taken into consideration in OSH management. Significantly, the materials and methods used to produce the machinery and prepare the workplace for operation are also considered important in design. This research has implications for designers, manufacturers, and suppliers, as it raises important questions about how to build capable machinery and sustain the performance for safety and health outcome. On the other hand, the challenge on how to foster safety and health matters in the design should be noted by the regulators and policymakers, as well as the key players in the industries, professionals, and institutions of education. The time has come for regulators, safety professionals, and those involved in design, manufacture, import, or supplies to collaborate to ensure the plant is designed and constructed to be safe and without risk to the health. The education and industry stakeholders need to work together to provide experimental learning programs to develop knowledge and skills to address safety and health matter in a design of workplace.

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