Hazard Identification, Risk Assessment and Risk Control in Chemical Industry

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Abstract. This study was aimed at identifying hazards through risk assessment and risk control by using HIRARC method in the warehouse of Company XYZ (a pharmaceutical company). Data was collected through direct observations, documentations, and interviews. The study found that Company XYZ identified 104 hazards in the year 2017, which were caused by poor working environment, worker attitudes, manual work, tools and machinery. This study revealed 57% of the total risks fall in medium category, 38% high, 5% low, and none of them are categorized under extreme risk. To control the risk, the company has been taking proactive actions through the elimination of risks, engineering, administration and Personal Protective Equipment (PPE).

1. Introduction

Almost all human activities may cause hazards, and it may happen anywhere. Especially at work, hazards are frequently caused by several factors, such as human negligence, unapplied procedures, unsupported equipment, human fatigue, and poor supervision [1]–[3]. When a hazard is occurring, which is commonly referred to as an accident, it may cause risks borne by humans, not only small risks but also high risks of death. Furthermore, an accident may incur high costs to the company, which ultimately give negative consequences to the company's profits [1], [3]–[6]. Some of the common approaches to minimize the risk are through hazard identification, risk assessment, and risks control based on the Occupational Safety and Health (OSH) rules and regulations [7], [8].

The work accidents in Indonesia showed a fairly high number [9]. According to the study conducted by International Labor Organization (ILO), out of 53 countries, Indonesia was ranked 52nd with poor OSH management [10], [11], [11]. The Social Security Administrator (Badan Penyelenggara Jaminan Sosial-BPJS) of Indonesia recorded that the number of occupational accidents in Indonesia tends to increase from time to time. A total of 123 thousand cases of workplace accidents were recorded throughout 2017 with the total insurance claim value of Rp 971 billion. Approximately, at the national level, there was a20% increment in the number of accidents compared to 2016. Especially in Jakarta, the increment was also very significant; up to 10 percent in 2017 [12], [13].

Work accidents may occur due to several factors, such as human error, incorrect device operation, lack of supervision as well as poor working condition. One of the industries with high risk of work accidents is the pharmaceutical industry [12]. This is because certain companies deal with very dangerous chemicals and equipment that may endanger to workers, especially in warehouse operations.

Warehouse is a vital element in a supply-chain [14], because it holds various company assets, raw materials, semi-finished goods (work in process), spare parts, finished goods, chemicals, etc. These assets have to be maintained properly to increase warehouse productivity [14], which in turn could increase company's productivity. Increasing warehousing productivity greatly depends on skills of workers and work situation [14].

Safety and security issues for the facilities in a warehouse include conveyors, material treatment through manual, fire safety, chemical exposure, lockout/tagout, use of forklifts [2], [10], [15], housekeeping, air emissions, noise and ergonomics [15], [16]. Some of the factors also frequently diminish the safety level of warehouse, which may affect safety workers and materials. Among of the factors are bad/damaged pallet conditions, irregular shelves' dimensions, non-compliant spaces, shelves load limits, distance between shelves, and less sturdy shelf support [17]. Exposure of awkward postures

and repetitive motions for pro-longed periods may lead to a variety of potential injuries and disorders of musculoskeletal tissues and/or peripheral nerves [1], [3]. Improper removal method can cause sprains and hand injuries. Workers' injuries and property damages do not only increase the company's operational costs (e.g., medical expenses, operational costs, compensations to the society and individuals, etc.), but it also harms its business reputation and decreases its market share [16]. Therefore, OSH is critical to be considered by everyone while working in warehouse areas. Consequently, company losses from various aspects (cost, time, injury, and productivity) could be minimized [17], [18].

Company XYZ (a pharmaceutical company) concerns about the issues related to OSH, especially related to warehousing activities. The purpose of this study is to identify, assess, and provide suggestions related to OSH and risks in the warehouse of Company XYZ by using Hazard Identification Risk Assessment and Risk control (HIRARC) method [7], [10], [15]. This research may benefit companies, managers, and practitioners on the method of how to minimize hazards, especially in a chemical warehouse.

2. Methods

This study applied HIRARC method, consisting of a series of OSH practices including identification of hazards, estimating of risks, and determining of control measures [15]. Risk assessment is aimed at identifying potential hazards while controlling risk in process, operations or activities at an acceptable level. Through the risk assessment, the likelihood of occurrence (L), and hazard severity (S) or consequence (C) were assessed. The likelihood of occurrence shows how possible the accident occurred, while the severity or consequence shows how severe the impact of the accident. The values of likelihood and severity will be used to determine risk rating or risk level [15].

In the risk-management standard AS/NZS 4360, risk is defined as the chance of something happening that will have the negative impact on the target, measured by the law of cause and effect. Risk is measured based on likelihood and consequence. The stages of the HIRARC in the context of warehouse are: identifying the workgroup in the warehouse, identifying hazards and risks that may occur, recording the frequency of hazards and risks, determining the likelihood level, determining the consequences' level, calculating the risk score, and determining the risk level.

3. Result

3.1 Identify activities in the warehouse

Activities in the warehouse are grouped into eight categories as shown in Table 1.

Table 1. Group of activities in the warehouse

No	Activities	Personal Protective Equipment used
1.	Incoming	Helmet and safety shoes
2.	Forklift	Helmet, body harness, and safety shoes
3.	Raw material Staging	Helmet, mask, back support, rubber gloves, and safety shoes
4.	Primary Container Material Staging	Helmet, back support, and safety shoes
5.	Secondary Packing Material Staging	Helmet and safety shoes
6.	Production Results Receipt Slip	Helmet and safety shoes
7.	Outgoing	Helmet and safety shoes
8.	Reject	Helmet, mask, cloth gloves, and safety shoes

3.2 *Identification of Hazards and Risks*

Hazards were identified for all the eight warehouse activities exhibited in Table 1 through direct field observations and interviews. Potential hazards and risks were identified, and records of hazards and risks identified in Year 2017 were also collected. Table 2 shows the examples of potential hazards and risks identified at the warehouse for the incoming process with loading and unloading activities.

Table 2. Hazards and risks identification of warehouse incoming process

Job Activity	Hazards	Risks
Loading and unloading of goods in the unloading area	Struck down by falling items	Bruises
	Pinched by goods	Sprained/dislocation, bruised
	Sliced by sharp objects	Wound
	Body movement errors	Backpain
	Foot is run over by hand pallet	Bruises
	Slip	Bruises
	Stumble	Bruises
	Items damaged/broken	Material loss
	Fatigue	Dehydration

3.3 *Frequency of Hazards and Risks*

Based on the 2017 records, the frequencies of each hazard and risk were counted. Statistics of hazard occurrences and risks in the year 2017 are presented in Table 3.

Table 3. Statistics of hazard occurances and risks in the warehouse incoming process in year 2017

Job Activity	Hazards	Risks	Frequency	Risk handling
		Incoming Process		
Loading and unloading goods in the unloading area	Struck down by falling items	Bruises	11	Need first aid
	Pinched by goods	Sprained/dislocation, bruised	12	Need first aid
	Sliced by sharp objects	Wound	12	Need first aid
	Body movement errors	Back pain	22	Rest, drink water
	Foot is run over by hand pallet	Bruises	11	Need medical treatment
	Slip	Bruises	21	Need first aid
	Stumble	Bruises	25	Need first aid
	Items damaged/broken	Material loss	18	No victims
	Fatigue	Dehydration	16	Drink water immediately.

3.4 *Determining likelihood and consequences levels*

Frequency data was used as a basis to determine the likelihood criteria (L), while handling of hazards was used as a basis to determine the severity criteria (Consequences-C). The criteria of determining the likelihood and consequences levels are presented in Tabe 4 and Table 5, respectively.

Table 4. Criteria of likelihood level

Likelihood Level	Frequency
1	0 – 5
2	6 – 10

3	11 – 15
4	16 – 20
5	21 – 25

Table 5. Criteria of consequence level

Level	Criteria	Explanation
1	Insignificant	No injuries, small financial losses
2	Minor	First aid, on-site handling, and medium financial losses
3	Moderate	Requires medical treatment, handling on-site with outside helps, large financial losses
4	Major	Severe injury, loss of production ability, handling outside the area without negative effects, large financial losses
5	Catastrophic	Death, poisoning out of the area with disturbing effects, large financial losses

3.5 Determining risk level

Risks were assessed based on multiplication of the ranking of likelihood and severity of consequences. Mathematically, it was quantified based on the formula: Risk level = Likelihood × Consequences. As a guideline, a risk matrix is presented in Table 6. Table 7 shows an example of risk level assessment results for warehouse incoming activities.

Table 6. Risk Matrix

Likelihood	*Consequence*				
	1	2	3	4	5
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Risk level	Risk score = *Likelihood* × *Consequences*
Extreme	Cannot accept risk, stop activities
high	Need to implement risk control
medium	Requires risk control
Low	Control measures may be needed

Table 7. Risk assessment results for warehouse incoming process

Job Activity	Hazard Identification	Risk	L	C	Risk level
Loading and unloading goods in the unloading area	Struck down by falling items	Bruises	3	2	6 (medium)
	Pinched by goods	Sprained/dislocation, bruised	3	2	6 (medium)
	Sliced by sharp objects	Wound	3	2	6 (medium)
	Body movement errors	Back pain	4	2	8 (high)
	Foot is run over by hand pallet	Bruises	3	3	9 (high)
	Slip	Bruises	5	2	10 (high)
	Stumble	Bruises	5	2	10 (high)
	Items damaged/broken	Material loss	4	1	4 (medium)
	Fatigue	Dehydration	4	1	4 (medium)

By applying the same procedure, the risk level assessment results for all the warehouse activities are presented in Table 8.

Table 8. Risk assessment results for all warehouse activities

No	Proses	Risk Level				PPE used
		Low	Medium	High	Extreme	
1	Incoming	1	9	7	0	Helmet and safety shoes
2	Forklift	0	2	3	0	Helmet, body harness and safety shoes
3	Raw material Staging	2	6	8	0	Helmet, mask, back support, rubber gloves, and safety shoes
4	Primary Container Material Staging	1	6	5	0	Helmet, back support, and safety shoes
5	Secondary Packing Material Staging	0	9	3	0	Helmet and safety shoes
6	Production Results Receipt Slip	1	14	4	0	Helmet and safety shoes
7	Outgoing	0	9	7	0	Helmet and safety shoes
8	Reject	0	4	3	0	Helmet, mask, cloth gloves and safety shoes
	Frequency	5	59	40	0	104
	Percentage of risk	5	57	38		

Based on Table 8, the frequency of risk level for all the warehouse activities is exhibited in Figure 1. Low risks are encountered in the process of incoming, staging of raw materials, primary packing material staging and production results acceptance slip, with a total low risk of 5%. In this case, control measures are required. Medium and risks were found in all the warehouse activities, with total incidence for medium and high risks are 57% and 38%, respectively. The medium risks require risk control, while the high risks need to implement risk control. No extreme risk encountered. Table 8 shows that the most common medium risks' occurrence were in the process of production results receipt slip, whereas the highest risks are encountered in the process of staging raw materials.

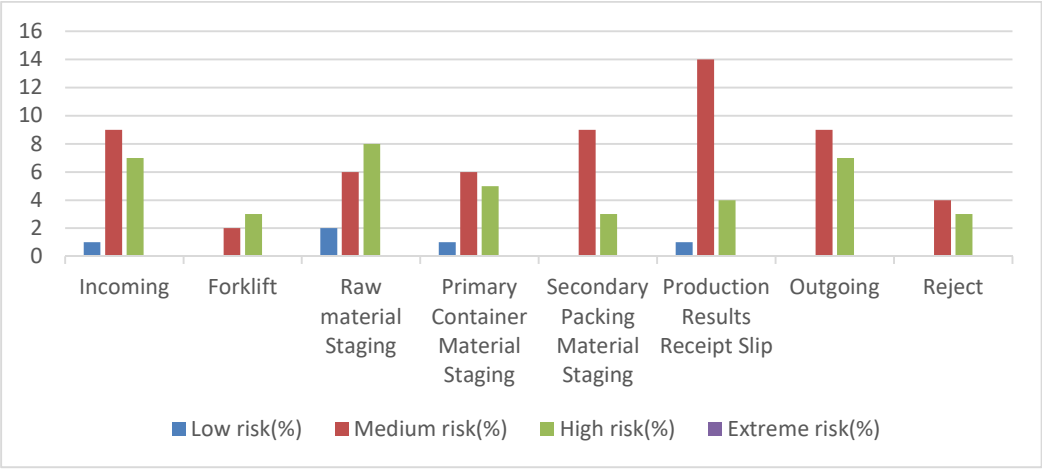

Figure 1. Frequency of risk level for each activity in the warehouse

This study revealed that the potential hazards in the warehouse under study is still high. Therefore, it is necessary to improve the warehouse operations system by applying the OSH program appropriately. The result of this study is in line with the study conducted by [19] who addressed that risk assessment using the HIRARC method is effective to deal with potential hazards or risks due to workplace accidents.

This study benefits managers, practitioners, and other related parties who deal with warehouse activities. This study can be used as a reference on how to apply HIRARC method to identify hazards that may occur and their risk level. Therefo2re, corrective actions can be taken appropriately.

4. Conclusions and Recommendations

The above data analysis and discussion lead to the following conclusions:

1. A total of 104 hazards were identified in 2017 at Company XYZ. The hazards were caused by poor work environment, employee attitudes, and lack of manual work, tools and machinery.
2. The study revealed three types of risks; medium risk (57%), high risk (38%), and low risk (5%), without any extreme risk.
3. Risk could be controlled by way of elimination, engineering, administration and PPE.

This study proposed the following suggestions in order to be able to improve occupational safety and health:

1. In order to avoid accidents, the company should prioritize the safety factors by applying the occupational safety SOP and paying attention to the use of PPE that has been provided by the company.
2. Risk assessment process should be carried out by experienced, competent personnel in assessing the level of consequences. Thus, the assessment results become more accurate.
3. In controlling the risks, safety officers should take preventive and corrective actions against the workers who do not comply with the work safety requirements.

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