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OSH risk analysis with hazard identification risk assessment and control (HIRARC) method at NPK Fertilizer Production Department of PT X

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ABSTRACT

According to BPJS Ketenagakerjaan (Social Security Management Agency of Manpower), there has been a constant increase in occupational accidents in the last 7 years, where by 2022 it reached 265.334. The NPK factory of PT X is a petrochemical factory that produces NPK fertilizer. In it's production process, it needs nitrogen, phosphate, kalium and clay as it's raw materials. In addition to the chemical materials for it's production purposes, PT X utilizes modern machineries to make the process easier. From this description, it can be concluded that the production of NPK fertilizer would create a number of hazards which may lead to occupational accidents (OA) as well as occupational diseases (OD). This study aims to analyze the OSH risks which are present at the NPK factory of PT X using the method of Hazard Identification Risk Assessment and Risk Control. This is a quantitative study with observational descriptive approaches. It was found out that before the implementation of risk control, the NPK factory of PT X had the extreme risk rate of 75%, high risk rate of 14%, and medium risk rate of 3% from the total of 28 existing hazards (100%). Upon the implementation of control on the 28 hazards, PT X experienced the decrease in risk rates as follows: high risk 11%, medium risk 23%, and low risk 7%. Keywords: OSH risk analysis, *Hazard Identification Risk Assessment And Control*.

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1. Background

According to the *International Labour Organization* (ILO), there were 1.8 million occupational fatalities during 2018 in Asia and Pacific. Two thirds of the occupational fatalities took place in Asia. The OSH accident rate has shown an increasing trend. Every year, 2.78 million workers die due to occupational accidents. More than 374 million people suffer from injuries or diseases caused by occupational accidents. In terms of the global economy, this has resulted in the loss of nearly 4% of the global Gross Domestic Product (ILO, 2018).

Frequent cases of occupational accidents should have been a matter of consideration by any company to improve the implementation of the OSH management system. Occupational accidents could be caused by two factors, namely the *unsafe condition* and *unsafe action*. To prevent occupational accidents from occurring, the step to take is identifying hazards which may arise from those two factors, which is then proceeded with making decisions on the proper control measures (Rudyarti, 2022).

The Government Regulation No. 50 of 2012 regarding the OSH Management requires companies to implement SMK3 (OSH Management System) in order to prevent the occurrence of occupational accidents and occupational diseases through hazard identification, OSH risk analysis, and risk control measures so that a safe work environment and employees' welfare are resulted (PPRI, 2012)

With such a background, the researchers conducted the study entitled *OSH Risk Analysis with Hazard Identification Risk Assessment and Control (HIRARC) Method at NPK Fertilizer Production Department of PT X* with the stages of hazard identification, OSH risk analysis, risk control, risk monitoring, and HIRARC implementation evaluation which were aimed at identifying the hazards of high risk jobs in the workplace, evaluating occupational accident risk using *Risk Matrix* by correlating between the employees and work environment, and finding out the implementation of HIRARC to minimize hazards in the workplace of PT X by providing recommendation for alternative risk controls of occupational accidents with the hierarchy of control which was suitable for the PT X situations and conditions (Cholil, 2020)

2. Research Methods

This is a quantitative study with observational descriptive approaches. The design of the study is descriptive in nature by providing objective description of a situation, providing factual description of hazards and risk analysis of NPK (Nitrogen Phosphate, Kalium) fertilizer production department of PT X. Risk identification was conducted using the HIRARC worksheet of PT X with standard risk matrix of AS/NZS 4360:2004, where the analysis was used to decide the level of risks based on the probability of the occurrence and the severity to be caused.

3. Results and Analysis

The results of risk evaluation of the NPK fertilizer production department of PT X using the risk matrix of AS/NZS 4360:2004 are as follows:

3.1. Results

3.1.1. Results of Hazard Analysis without Control

a. *Feeding Process*

In the feeding process, there was 1 hazard namely dust exposure with an extreme risk (100%) score. This was due to the high presence of dust from clay and other chemical matters which were not properly loaded.

Table 1.3 Identification of Hazards Without Control in the Feeding Process

No	Hazard	Factors Causing Occupational Accidents					EFFECT	Risk Without Control		
		Human	Material	Methode	Machine	Environment		K	D	R
Feeding Process										
1.	Chemical Dust Exposure		Raw materials (clay, rock phosphate, dolomite)				Eye irritation, skin irritation, breathing difficulties, Acute Respiratory Infections (ARI)	5	3	**15 *(Extreme risk)***

b. Granulation Process

Continued with the second process namely granulation. This process presented 2 hazards namely slipping and hitting with risk values of extreme risk (50%) and medium risk (50%).

Table 2.3 Hazard Identification Without Control in Granulation Process

No	Hazards	Factors Causing Occupational Accidents					EFFECT	Risk Without Control		
		Human	Material	Method	Machine	Environment		K	D	R
Granulation Process										
1.	Slipping		Raw materials (clay, rock phosphate, dolomite)		Leak on granulator machine	Dust accumulation due to leak on product processing machine causing slippery floor	Sprained, hit Bone dislocation	5	3	***15 (Extreme risk)***
2.	Hitting	Less concentration, fatigue					Injury	2	3	**6 *(Medium risk)***

c. Drying Process

In the third process of drying, there were 4 hazards namely being hit or struck by iron balls with a risk value of *medium risk* (25%), noise with a risk value of *extreme risk* (25%), explosion with a risk value of *extreme risk* (25%), and product dust with a risk value of *extreme risk* (25%).

Tabel 3.3 Hazard Identification Without Control in Drying Process

No	Hazards	Factors Causing Occupational Accidents					EFFECT	Risk Without Control		
		Human	Material	Method	Machine	Environment		K	D	R
Drying Process										
1.	Hit by iron balls of drying machine	Negligence			Leak on drying machine		permanent disability, fatality	1	5	**5 *(medium risk)***
2.	Noise				resulting from drying machine		degradation of hearing ability	5	3	**15 *(extreme risk)***
3.	Explosion		Heat produced by furnace				burning	3	5	**15 *(Extreme risk)***
4.	Product Dust				resulting from drying machine		ARI, irritation of skin, eye, and respiratory system	5	3	**15 *(Extreme risk)***

d. Cooling Process

In the cooling process, there were three hazards namely being hit by iron balls with m*edium risk* (33,33%), noise with *extreme risk* (33,33%), and product dust with *extreme risk* (33,33%).

Table 4.3 Hazards Identification Without Control in Cooling Process

No	Hazard	Factors Causing Occupational Accidents					EFFECT	Risk Without Control		
		Human	Material	Method	Machine	Environment		K	D	R
Cooling Process										
1.	Hit by iron balls of cooling machine	Negligence			Leak in cooling machine		permanent disability, fatality	1	5	**5 *(medium risk)***

2.	Noise			Resulting from cooling machine	degradation of hearing ability	5	3	**15 *(extreme risk)***
3.	Product dust			Resulting from cooling machine	ARI, irritation of skin, eye, and respiratory system	5	3	**15 *(Extreme risk)***

e. Screening Process

In the fifth process of screening, there were 3 hazards namely falling from height with a risk value of *extreme risk* (33,33%), dust exposure with *extreme risk* (33,33%), and ergonomics with *extreme risk* (33,33%).

Table 5.3 Hazard Identification Without Control in Screening Process

No	Hazards	Factors Causing Occupational Accidents					EFFECT	Risk Without Control		
		Human	Material	Method	Machine	Environment		K	D	R
Screening Process										
1.	Falling from height		Corrosion of grating floor				Fatality Injury	3	5	15 *(Extreme risk)*
2.	Chemical dust exposure from production process					NPK dust	eye irritation, skin irritation, respiratory disorder	5	3	15 *(Extreme risk)*
3.	Ergonomics	Neglecting work posture		repetitive movement			Back pain, muscle cramp	5	3	15 *(Extreme risk)*

e. Coating Process ergonomics with *extreme risk* (20%), falling from height with *extreme risk* (20%), slipping with *extreme risk* (20%), heat from coating machine with *high risk* (20%), exposure to dust with *extreme risk* (20%).

Table 6.3 Hazard Identification Without Control in Coating Process

No	Hazard	Factors Causing Occupational Accidents					EFFECT	Risk Without Control		
		Human	Material	Method	Machine	Environment		K	D	R
Proses Coating										
1.	Ergonomics			Repetitive movement if refilling			Muscle Cramp, sprain,	5	3	15 *(Extreme risk)*
2.	Falling from height		Corrosion of grating floor				Fatality Injury	3	5	15 *(Extreme risk)*
3.	Slipping					Slippery condition caused by raw materials	Sprained, hit, bone dislocation.	5	3	**15** *(Extreme risk)*
4.	Heat from coating machine	Fatigue, less concentration		Heat generated by machine			Burn	3	3	**9 *(High risk)***
5.	Exposure to product dust					Unprocessed product dust	Eye irritation, skin irritation, respiratory disorder	5	3	15 *(Extreme risk)*

f. Bagging & Sewing Process

In the seventh process of bagging & sewing, there were 2 hazards namely ergonomics with *extreme risk* (50%) and exposure to dust with *extreme risk* (50%).

Table 7.3 Hazard Identification Without Control in Bagging & Sewing Process

No	Hazards	Factors Causing Occupational Accidents					EFFECT	Risk Without Control		
		Human	Material	Method	Machine	Environment		K	D	R
Bagging & Sewing Process										
1.	Ergonomics			Static movements			Muscle cramp, sprain	5	3	15 *(Extreme risk)*
2.	Exposure to NPK dust					NPK dust	Skin irritation, eye irritation, respiratory disorder	5	3	15 *(Extreme risk)*

g. Electric Panel Area

In the electrical panel area, there was 1 hazard namely electric current with *high risk* (100%).

Table 8.3 Hazard Identification Without Control in Electrical Panel Area

No	Hazards	Factors Causing Occupational Accidents					EFFECT	Risk Without Control		
		Human	Material	Method	Machine	Environment		K	D	R
Electrical Panel Area										
1.	Electric Current				Peeled off cables, falling of cable tray		Electrical shock	2	4	8 *(High Risk)*

h. Production Area

In the production area, there were 4 hazards namely being hit by building materials with *extreme risk* (20%), noise with *extreme ris*k (20%), slipping with *extreme risk* (20%), being pinched by rotating equipment with *high risk* (20%).

Table 9.3 Hazard Identification Without Control in Production Area

No	Hazards	Factors Causing Occupational Accidents					EFFECT	Risk Without Control		
		Human	Material	Method	Machine	Environment		K	D	R
Production Area										
1.	Hit by building materials		Corrision					3	5	15 *(Extreme Risk)*
2.	Noise				Drying and cooling machines		Degradation of hearing ability	5	3	15 *(Extreme Risk)*
3.	Slippery		Raw materials				Slipping, bone dislocation and fracture	5	4	20 *(Extreme Risk)*
4.	Pinched by rotating equipment	Fatigue			Rotating movement of cooling machine		Sprained, hit, bone dislocation, fracture	3	4	**12 *(High Risk)***

i. Reject Process

In the reject process, there were 3 hazards namely being cut with *high risk* (33,33%), exposure to dust with *extreme risk* (33,33%), and ergonomics with *extreme risk* (33,33%). With a total of 28 hazards, there have been 21 extreme risks (75%), 4 high risks (14%), and 3 medium risks (11%).

Table 10.3 Hazard Identification Without Control in Reject Process

No	Hazards	Factors Causing Occupational Accidents					EFFECT	Risk Without Control		
		Human	Material	Method	Machine	Environment		K	D	R
Reject Process										
1.	Being cut	Fatigue, less concentration					Cutting wound	3	3	9 *(high risk)*
2.	Exposure to product dust					Work area exposed to chemical dust from production process	Eye irritation, skin irritation, ARI	5	3	15 *(Extreme Risk)*
3.	Ergonomics	Negligence of work postures		Repetitive movement			Back pain, muscle injury	5	3	15 *(Extreme Risk)*

3.1.2. Results of Hazard Analysis With Control

There was 1 hazard in the feeding process namely exposure to dust with a risk value of medium risk (100%). Then, there were 2 hazards in the second process, the granulation process, namely being hit and slipping with risk values of low risk (50%) and medium risk (50%), respectively. In the third process, the drying process, there were 4 hazards namely being hit by iron balls with a risk value of medium risk (25%), noise with medium risk (25%), explosion with medium risk (25%), and product dust with medium risk (25%). In the fourth process, the cooling process, there were 3 hazards namely being hit by iron balls with medium risk (33.33%), noise with medium risk (33.33%), and product dust with medium risk (33.33%). In the fifth process, the screening, there were 3 hazards namely falling from height with a risk value of medium risk (33.33%), exposure to dust with medium risk (33.33%), and ergonomics with medium risk (33.33%). In the sixth process, the coating process, there were 5 hazards namely ergonomics with medium risk (20%), falling from height with medium risk (20%), slipping with low risk (20%), heat from coating machine with medium risk (20%), and exposure to dust with medium risk (20%). In the seventh process, the bagging and sewing, there were 2 hazards namely ergonomics with medium risk (50%) and exposure to dust with high risk (50%). In the electrical panel area, there was 1 hazard namely electric shock with medium risk (100%). In the production area, there were 4 hazards namely being hit by building materials with medium risk (20%), noise with high risk (20%), slippery with high risk (20%), and being pinched by rotating equipment with medium risk (20%). In the reject process, there were 3 hazards namely being cut with medium risk (33.33%), exposure to dust with medium risk (33.33%), and ergonomics with medium risk (33.33%). With a total of 28 hazards, there were 3 high risks (11%), 23 medium risks (82%), and 2 low risks (7%).

3.1.3. *List of Additional Controls*

In the list of additional controls, only 13 of 28 hazards were provided with controls. In the feeding process, there was 1 hazard namely exposure to dust with a risk value of low risk (100%). Then, in the drying process, there was 1 hazard namely being hit by iron balls with a risk value of low risk (100%). In the cooling process, there was 1 hazard namey being hit by iron balls with low risk (100%). In the screening process, there were 2 hazards namely exposure to dust with medium risk (50%) and ergonomics with low risk (50%). In the coating process, there was 1 hazard namely ergonomics with low risk (100%). In the bagging and sewing process, there were 2 hazards namely ergonomics

with low risk (50%) and exposure to dust with medium risk (50%). In the electrical panel area, there was 1 hazard namely electric current with medium risk (100%). In the production area, there were 2 hazards namely being hit by building materials with medium risk (50%) and slippery conditions with medium risk (50%). In the reject process, there were 2 hazards namely exposure to dust with medium risk (50%) and ergonomics with medium risk (50%). There were a total of 7 medium risks (11%) and 6 low risks (82%).

3.2. Discussion

a. Feeding Process

In the feeding process, there was a risk of exposure to dust. This was caused by the presence of chemical dust from the raw materials namely the Nitrogen from the Urea, Phosphate from Diammonium phosphate, and Kalium from KCl. According to the MSDS (Material Safety Data Sheet) of Urea fertilizer of PT X, the hazards from the urea were skin irritation, eye irritation, and respiratory irritation. According to the Presidential Regulation No. 7 of 2019 on Occupational Diseases, one of the chemicals causing diseases is the phosphorus and its derivatives, where diammonium phosphate is one of the phosphorus derivatives utilized as a raw material in the production of NPK fertilizer (Sopiany, 2017)

Therefore, hazards coming from this raw material should be controlled immediately. The NPK factory of PT X has conducted control measures by enforcing a regulation which requires all visitors to the production area to wear masks. This is in line with the Regulation of Manpower and Transmigration Minister No. 8 of 2010 on Personal Protective Equipment Clause 2 Paragraph 1 that a company should provide personal protective equipment (PPE). This is further supported by the Regulation of Manpower Minister No. 5 of 2018 Chapter II Clause 7 Paragraph 3 regarding the control by providing PPE (Gunawan, 2021).

b. Granulation Process

In the granulation process, there was a slipping hazard. This was due to the presence of hazard caused by raw materials such as clay and phosphate originating from the Diammonium phosphate (DAP) which has hygroscopic nature or easily absorbing water as one of its characteristics. Because of this, the work area became slippery from the mud resulting from the spill of raw materials and the improperly handled dust. Every time the granulation process area was covered with spills of raw materials so that every worker was at risk of slipping. As such, a score of 5 was given for the probability, whereas the severity due to the slipping was scored 3 meaning that it would result in injury with light loss (Heny, 2014)

The risk value was 15 (extreme risk) without control. Control measures were then implemented by conducting routine cleaning and application of rubber boots to minimize slipping hazard and lower the score into 1 meaning that it might happen in unpredictable conditions with a severity score of 2 meaning that it would cause light injury which would require first aid treatment. The risk value changed into 2 (low risk) meaning that it required monitoring measures to ensure that control measures be implemented properly. In addition to slipping hazards, there was the hitting hazard. This was due to the possible trouble in the granulation machine where it would be stopped by having the employee in-charge check and enter the disabled granulation machine. Since the entry gate of the machine was not so tall, the employee should duck slightly. In the machine there were small iron parts which were designed protruding to stir the product materials. If the workers had less concentration, there would be the risk of hitting. The possibility of hitting was scored 2 since it might happen in a certain condition but the possibility was low and the severity was scored 3 meaning that it might result in serious injury requiring hospitalization. The total was 6 (medium risk). Then, control measures were implemented by having the workers wear safety helmets so that the score of the hitting possibility was reduced into 2 meaning that it might happen in a certain condition but the possibility was low with the severity score of 2 meaning that it might result in light injury requiring first aid treatment (Dahlan, 2017).

The risk value became 4 (medium risk) meaning that it required attention and additional procedures. The Law No. 1 of 1970 Chapter V regarding Coaching Clause 9 Paragraph 1 mentions that the management is required to conduct socialization of hazards in a workplace, provide personal protective equipment, and communicate safe work practices (work procedures, work instruction, posters, danger signages in a work area, etc). In complying with the obligation, the management of PT X have conducted the activities in accordance with the Law No. 1 of 1970 Chapter V regarding Coaching Clause 9 Paragraph 1. It was proved with the implementation of control measures such as provision of personal protective equipment (PPE) and preparation of operational instruction for the granulation process. The provision of PPE has been implemented by PT X in accordance with the Regulation of Minister of Manpower No. 5 of 2018 Chapter II Clause 7 Paragraph 3 regarding control measure in the form of provision of PPE. (Lazuardi, 2022)

c. Drying Process

In the drying process, there was a hazard of being hit by iron balls of the drying machine. This was due to the presence of acidic KCL which would make iron materials get corroded easily whereas the drying machine was made from iron. Inside the drying machine there were iron balls for production processing purposes. If the drying machine gets corroded, its surface would be thinner which might result in the falling out of the iron balls and might hit the workers who were moving around in the area. Workers frequently walked under the drying machine as the entry and exit path of the factory. The frequency of this occurrence was scored 1 meaning that it might happen in an unpredictable moment with a severity score of 5 meaning that it might result in a fatality. The risk value was 5 (medium risk). Control measures implemented by having the workers wear safety helmets had reduced the severity score into 4 meaning serious injury which might result in permanent disability. The risk value became 4 (medium risk) meaning that it required attention and additional procedures. In addition to being hit by iron balls, this process presented a noise hazard due to the ball crashing inside the drying machine. The noise was heard all the time so that the noise frequency was scored 5, meaning that it happened almost always in every situation (Arifin, 2022)

The severity score was 3, meaning that it required hospital treatment. Control measures were implemented by having the workers wear earplugs every time they entered the work area. This reduced the frequency score into 2, meaning that it might happen only in certain conditions but with low possibility. The severity was scored 3. The risk value was reduced into 6 (medium risk), meaning that it required special attention and additional procedures. There was an explosion hazard. It might be caused by the furnace machine which served to generate heat for the drying machine. The generated heat was roughly 250^{o}C and, if it was not properly monitored or not well-maintained, it might result in explosion. The frequency score was 3, meaning that the accident might happen in a certain condition with a severity score of 5, meaning that it might cause a fatality or major loss. The risk score was 15 (extreme risk). Control measures were implemented by putting a temperature measuring tool which could be accessed from the control room so that the temperature could be monitored all the time. The frequency score decreased to 1, meaning that the accident might happen in a certain unpredictable situation. The next was the presence of the Fire Rescue unit that has been trained and had expertise in dealing with emergency situations. Therefore, the severity score decreased to 3, namely serious injury, which required hospital treatment. The risk value became 3 (medium risk), meaning that it required attention and additional procedures. Further, the hazard of production dust resulting from the cooling process has caused the work area (environment) to be dusty and definitely dangerous for the workers and the environment (Dahlan, 2017).

The score for the frequency of the production dust was 5, meaning that the accident always happened in every situation. The severity score was 3, meaning that it required hospital treatment. With a risk score of 15 (extreme risk), PT X implemented control measures by installing a dust vacuum cleaner (Cyclone) to reduce the exposure to dust as well as providing masks and glasses for the workers. Therefore, the frequency score decreased to 3

and the severity score was 2. The risk value became 6 (medium risk), meaning that it required attention and additional procedures. According to the Minister of Manpower Regulation No. 13 of 2011 on the maximum level and factor of chemicals in a work area as mentioned in Chapter II, the maximum level of noise is 85dB within 8 working hours. The value beyond 85 dB with 8 working hours per day, control measured should be implemented. This has been implemented by the NPK factory of PT X by providing PPE of earplugs for the workers entering the NPK factory area of PT X. This was in accordance with the Minister of Manpower Regulation No. 5 of 2018 Chapter II Clause 7 Paragraph 3 regarding the control of work area by providing PPE (Lazuardi, 2022)

The Government Regulation No. 11 of 1979 on the Occupational Safety at Oil and Gas Refinery and Processing Chapter II regarding the Building at Clause Paragraph 1 mentions that, prior the construction of a factory, an permanent installation should be made to prevent fire, either with water or chemical involvement. In addition to these regulations, there is the Minister of Manpower Decree No. 186 of 1999 Clause 2 which mentions that a company is obliged to implement prevention, minimization, and extinguishing of fire as well as conduct training on fire extinguishing. Regarding the explosion hazard, control measures have been implemented in accordance with the above-mentioned regulations. This was proved with the installation of pressure gauge, hydrants, provision of fire extinguishers, and presence of Fire and Rescue Unit (FRU) that had expertise in dealing with fire and emergency situations. This has been consistent with the Minister of Manpower Decree No. 186 of 1999. Nevertheless, the fire protection system of the NPK factory has not been considered enough since there were still insufficient fire protection systems such as fire alarms, sprinklers, fire detectors, etc. According to the MSDS (Material Safety Data Sheet) of the Urea of PT X, the hazards sourced from urea include skin irritation, eye irritation, and respiratory irritation. The Regulation of the President of the Republic of Indonesia No 7 of 2019 on occupational diseases mentions that the diseases caused by chemical factors include among others those caused by phosphorus and its derivatives, whereas diammonium phosphate is included in one of the phosphorus derivatives used as raw material in the manufacturing of NPK fertilizer. Therefore, hazards from this material should be controlled. The NPK factory of PT X has implemented control measures by requiring the workers entering the production area to wear masks and installing cyclones. This has been consistent with the Minister of Manpower Regulation No. 8 of 2010 on the Personal Protective Equipment Clause 2 Paragraph 1 which mentions that an employer/company is obliged to provide personal protective equipment. It is also reinforced with the Minister of Manpower Regulation No. 5 of 2018 Chapter II Clause 7 Paragraph 3 regarding control measures in the forms of engineering control and provision of PPE (Urrohmah, 2019)

d. Cooling Process

In the cooling process, there was a hazard of being hit by iron balls of the cooling machine (cooler). This was due to the presence of acidic KCl which would easily make iron materials get corroded, whereas the cooling machine was made of iron. Inside the cooling machine there were relatively heavy iron balls for production processing purposes. If the cooler got corroded which would cause the machine surface to be thinner, this could end in the possibility of the iron balls inside the machine hitting the thin surface and might result in the iron balls falling out and hitting the workers passing by underneath. The workers frequently passed by under the cooler which functioned as a walking path. The frequency of such an accident was scored 1, meaning that it might occur in an unpredictable situation with a severity score of 5, meaning that it might cause fatalities. The risk value was 5 (medium risk). Control measures implemented by having the workers wear safety helmets have decreased the severity score into 4, meaning that it might result in serious injury and permanent disability. The risk value decreased into 4 (medium risk) meaning that it required attention and additional procedures. Besides the hazard of being hit by iron balls, there was a hazard of noise resulting from the crash of iron balls inside the cooling machine (Gunawan, 2021)

The noise was heard all the time so that the noise frequency was scored 5, meaning that it occurred almost always in every situation. The severity score was 3, meaning that it would require hospital treatment. Control measures were then implemented by having the workers wear earplugs every time they enter the work area. This could reduce the frequency score into 2, meaning that it would occur in a certain situation but the possibility was low. The severity score stayed 3. Then, the risk value decreased into 6 (medium risk), meaning that it required attention and additional procedures. The hazard of dust resulting from the cooling process has caused the work area to be dusty and it certainly became dangerous for the workers and the environment. The frequency of dust hazards was scored 5, meaning that it would happen in almost every situation. The severity score was 3, meaning that it would require hospital treatment. With a risk score of 15 (extreme risk), PT X implemented control measures in the forms of installation of dust vacuum cleaner (cyclones) to reduce the exposure to dust and provision of masks for the workers. Then, the frequency score decreased into 2. The risk value decreased into 6 (medium risk), meaning that it required attention and additional procedures. Minister of Manpower and Transmigration Regulation No. 13 of 2011 on the maximum threshold for chemical components in a workplace Chapter II mentions that the maximum level of noise is 85 dB within 8 working hours. The level above 85 dB with the same working hours requires control measures (Arifin, 2022)

This has been done by the NPK factory of PT X, which was proved by the preparation of regulation for wearing earplugs for everyone who would enter the area of the NPK factory. According to the MSDS of the urea fertilizer of PT X, the hazards of urea fertilizer include skin irritation, eye irritation, and respiratory irritation. According to the Regulation of the President of the Republic of Indonesia No. 7 of 2019 on occupational diseases, one of the chemicals causing the diseases is phosphorus and its derivatives. Diammonium phosphate is one of the derivatives and is used in the manufacturing of NPK fertilizer. Therefore, hazards from this raw material should be controlled. The NPK factory of PT X has implemented control measures by requiring the workers entering the work area to wear masks and by installing cyclones. This was in accordance with the Minister of Manpower Regulation No. 8 of 2010 on Personal Protective Equipment Clause 2 Paragraph 1 mentioning that an employer or a company is obliged to provide Personal Protective Equipment. It is reinforced with the Minister of Manpower Regulation No. 5 of 2018 Chapter II Clause 7 Paragraph 3 regarding control measures in the forms of engineering control and provision of PPE (Rudyarti, 2023)

e. Screening Process

In the screening process, there was a hazard of falling from height. This was because there were workers who did the screening jobs on a height while stepping on a floor made of iron grating which was susceptible to corrosion due to the presence of improperly handled dust. The frequency score for the hazard of falling from height was 3, meaning that it would occur in a certain condition. The severity score was 5, meaning that it could result in fatalities due to falling from height. The risk value was 15 (extreme risk). Control measures were implemented with the replacement of corroded gratings with the new ones, request for repair to the workshop section, and application of body harness for workers doing the jobs on height. These control measures reduced the frequency score into 2, meaning that it might happen in a certain condition but with low possibility. The severity score was 2, meaning that it would result in light injuries requiring first aid treatment. The risk value became 4 (medium risk), meaning that it required attention and additional procedures. Besides falling from height, there was a hazard of exposure to chemical dust sourced from the production dust which was not handled properly. The frequency score of the hazard of exposure to dust was 5 since as long as there was a production process there would be dust. The severity score was 3, meaning that it would require hospital treatment. The risk value was 15 (extreme risk). Control measures were implemented by replacing (rotating) workers every 2 hours to reduce the score of dust exposure hazard into 3 and the application of masks to reduce the severity score into 2, meaning it could be treated with first aid treatment. (Permenaker, 2018)

The risk value became 6 (medium risk), meaning that it required attention and additional procedures. The next hazard was the ergonomics. It was caused by bending work posture done repetitively which might result in back pain and muscle cramps. The frequency score was 5, meaning that it might occur in every situation. The severity score was 3, meaning that it required hospital treatment. Control measures were implemented by replacing (shift rotating) the workers every 2 hours to reduce the frequency score into 2 and the severity score became 3, meaning that it could be treated with first aid treatment. The risk value became 6 (medium risk), meaning that it required attention and additional procedures. Minister of Manpower Regulation No. 9 of 2016 on Occupational Safety and Health for Working on Height Chapter II Clause 4 mentions that an employer or a company is obliged to ensure that the jobs be executed safely in proper ergonomic condition. The NPK factory of PT X implemented control measures by replacing the corroded grating floors with the new ones. This was in accordance with the above-mentioned regulation where the management should ensure the safety of working on height. Besides replacing them with new gratings, PT X also proposed additional control measures in the form of replacing the iron gratings with plastic gratings. According to the MSDS of urea fertilizer of PT X, the hazards from urea might result in skin irritation, eye irritation, and respiratory irritation. According to the Regulation of the President of the Republic of Indonesia No. 7 of 2019 on occupational diseases, one of the chemicals causing occupational diseases is phosphorus and its derivatives. Whereas, diammonium phosphate is one of the phosphorus derivatives which is used in the production of NPK fertilizer (Permenaker, 2016)

Therefore, the hazards caused by this raw material should be controlled immediately. The NPK factory of PT X has implemented controls by imposing a regulation where everyone entering the production area is obliged to wear a mask. This has been in accordance with the Minister of Manpower and Transmigration Regulation No. 8 of 2010 on Personal Protective Equipment Clause 2 Paragraph 1 mentioning that a company is obliged to provide Personal Protective Equipment for the workers in the workplace. The Minister of Manpower and Transmigration Regulation No. 8 of 2018 on Occupational Safety and Health of Work Environment Section 5 of Ergonomic Factor Clause 23 mentions that ergonomic factors may cause occupational diseases due to work practices, work positions, and body postures which do not conform with the anthropometry of the workers. In the coating process there was an ergonomic hazard caused by awkward work positions. Therefore, PT X has implemented control measures in the form of rotating the workers every 2 hours to reduce the frequency of work with awkward positions to fulfill the requirement of environmental OSH in accordance with the Minister of Manpower Regulation No. 5 of 2018 Chapter II Clause 7 Paragraph 3 namely the administration control. (Permenaker, 2018)

f. Coating Process

In the coating process, there was an ergonomic hazard. This was due to the bending work posture with repetitive movement which might cause complaints of back pain and muscle cramps. The frequency score was 5, meaning that it might happen in every condition. The severity score was 3, meaning that it required hospital treatment. Therefore, controls were implemented by rotating the workers every 2 hours to reduce the frequency score to 3 and the severity score to 2, meaning that it could be handled with first aid treatment. The risk value was 6 (medium risk), meaning that it required attention and additional procedures. Besides ergonomic hazards, there was also the hazard of falling from height. This was because there were workers who did the screening jobs on a height while stepping on a floor made of iron grating which was susceptible to corrosion due to the presence of improperly handled dust. The frequency score for the hazard of falling from height was 3, meaning that it would occur in a certain condition. The severity score was 5, meaning that it could result in fatalities due to falling from height. The risk value was 15 (extreme risk). Control measures were implemented with the replacement of corroded gratings with the new ones, request for repair to the workshop section, and application of body harness for workers doing the jobs on height. (Urrohmah, 2019)

These control measures reduced the frequency score into 2, meaning that it might happen in a certain condition but with low possibility. The severity score was 2, meaning that it would result in light injuries requiring first aid treatment. The risk value became 4 (medium risk), meaning that it required attention and additional procedures. The next hazard was slipping. This was due to the presence of raw materials such as clay and phosphate sourced from Diammonium phosphate (DAP) where one of its characteristics is hygroscopic (easily absorb water). That is why the work area became slippery due to the presence of much mud from the spills of raw materials which were not handled properly. Every time in the work area, the spills of raw materials were scattered on the coating area so that every time the workers were at risk of slipping. Therefore, the possibility score was 5, while the severity score was 3, meaning that it might cause injuries with minor loss. The risk value was 15 (extreme risk) without control. Then, control measures were implemented by conducting routine weekly cleaning and wearing of rubber boots so that the score of the possibility of slipping decreased into 1, meaning that it might happen in an unpredictable condition. The severity score decreased into 2, meaning that it might cause light injuries requiring first aid treatment. The risk value became 2 (low risk), meaning it required monitoring to ensure the control measures run well. The next was the heat hazard which was caused by the production machine which might cause burn injuries. If the workers were not careful, they might get into contact with the hot parts of the machine and get burn injuries. As such, the frequency score was 3, meaning that it might happen in a certain condition (Permenaker, 2015).

The severity score was 3, meaning it might cause major injuries requiring hospital treatment. Control measures were implemented by rotating the workers every 2 hours and having them wear long-sleeve shirts and gloves to reduce severity. The severity score decreased into 2, meaning that it might cause light injuries requiring first aid treatment. Then, there was a hazard of exposure to dust resulting from the raw materials which were not handled properly so that they were dispersed and might get the coating workers exposed. The frequency score was 5 since dust would always be present as long as there is a production process. The severity score was 3, meaning that it would require hospital treatment. The risk value was 15 (extreme risk). Control measures were implemented by rotating the workers every 2 hours and wearing masks during work so that the frequency score was reduced to 3 and the severity score was reduced to 2, and the risk value became 6 (medium risk), meaning that it required attention and additional procedures. The Minister of Manpower Regulation No. 5 of 2018 on the Occupational Safety and Health for Work Environment Part Five regarding Ergonomic Factors Clause 23 mentions that ergonomic factors may cause occupational diseases due to work practices, work positions, and work postures which do not conform the anthropometry of workers. In the coating works, there was an ergonomic hazard caused by awkward work postures. Therefore, PT X has implemented controls by rotating the workers every 2 hours to reduce the frequency of awkward work postures and to fulfill the requirements for the OSH of the work environment in accordance with the Minister of Manpower Regulation No. 5 of 2018 Chapter II Clause 7 Paragraph 3 regarding implementation of administration control. The Minister of Manpower Regulation No. 9 of 2016 on the Occupational Safety and Health for Working on Height Chapter II Clause 4 mentions that an employer or a company is obliged to ensure that the work be executed safely and in appropriate ergonomic conditions. The NPK factory of PT X has implemented controls by replacing the corroded grating floors with the new ones. This was in accordance with the above-mentioned regulation mentioning that the management is obliged to ensure the safety of the workplace on height (Permenaker, 2018).

In addition to replacing the gratings with the new ones, PT X also proposed an additional control measure namely the replacement of iron gratings with plastic gratings. In the Law No. 1 of 1970 Chapter V on Coaching (Guidance) Clause 9 Paragraph 1, it is mentioned that a company is obliged to conduct socialization in a workplace, provide personal protective equipment, and deliver safe work practices (work procedures, work instructions, posters, precaution signages in a workplace, etc) to the workers. As an effort to implement

control of hazard resulting from the production machine which might cause burn injuries and to comply with the obligation, PT X has conducted the activities in accordance with the Law No. 1 of 1970 Chapter V regarding Coaching (Guidance) Clause 9 Paragraph 1. This was proved with the implementation of controls in the forms of the provision of personal protective equipment and routine weekly cleaning in accordance with the Minister of Manpower Regulation No. 5 of 2018 Chapter II Clause 7 Paragraph 3 regarding implementation of administration control. According to the MSDS of urea fertilizer of PT X, the hazards caused by urea include skin irritation, eye irritation, and respiratory irritation. According to the Presidential Regulation No. 7 of 2019 on occupational diseases, one of the materials causing diseases due to chemical factors is phosphorus and its derivatives. Whereas, diammonium phosphate is one of the derivatives which is used in the production of NPK fertilizer. Therefore, hazards caused by this raw material should be controlled immediately. The NPK factory of PT X has implemented controls by establishing regulations requiring everyone entering the production area to wear a mask (Perpres, 2019).

g. Bagging & Sewing Process

The hazard which was present in the bagging & sewing process was the ergonomics. It was caused by the static work posture of the workers where they had to stand all the time so that leg muscle cramps might occur. The frequency score was 5, meaning that it might happen in any situation. The severity score was 3, meaning that it required hospital treatment. Therefore, controls were implemented by rotating the workers every 2 hours to reduce the frequency score to 3 and the severity score to 2, meaning that it required first aid treatment. The risk value was 6 (medium risk), meaning that it required attention and additional procedures. Beside ergonomic hazards, there was dust exposure hazard resulting from the improperly handled raw materials so that the dust was dispersed and exposed to the workers in the coating section. The frequency score was 5 since dust would always be present as long as there was production. The severity score was 3, meaning that it required hospital treatment. The risk value was 15 (extreme risk). Control measures were implemented by rotating the workers every 2 hours and wearing masks. This reduced the frequency value to 3 and the severity score was reduced to 2. The risk value became 6 (medium risk), meaning that it required attention and additional procedures. The Minister of Manpower Regulation No. 5 of 2018 on the Occupational Safety and Health for Work Environment Part Five regarding Ergonomic Factors Clause 23 mentions that ergonomic factors may become the causes of occupational diseases due to work practices, work positions, and work postures which do not conform the anthropometry of workers. In the coating works, there was an ergonomic hazard caused by awkward work postures. Therefore, PT X has implemented controls by rotating the workers every 2 hours to reduce the frequency of awkward work postures and to fulfill the requirements for the OSH of the work environment in accordance with the Minister of Manpower Regulation No. 5 of 2018 Chapter II Clause 7 Paragraph 3 regarding implementation of administration control. According to the MSDS of urea fertilizer of PT X, the hazards caused by urea include skin irritation, eye irritation, and respiratory irritation. According to the Presidential Regulation No. 7 of 2019 on occupational diseases, one of the materials causing diseases due to chemical factors is phosphorus and its derivatives (Perpres, 2019)

Whereas, diammonium phosphate is one of the derivatives which is used in the production of NPK fertilizer. Therefore, hazards caused by this raw material should be controlled immediately. The NPK factory of PT X has implemented controls by imposing a regulation where everyone entering the production area is obliged to wear a mask. This has been in accordance with the Minister of Manpower and Transmigration Regulation No. 8 of 2010 on Personal Protective Equipment Clause 2 Paragraph 1 mentioning that a company is obliged to provide free Personal Protective Equipment for the workers in the workplace. 8. Electrical Panel Area. In the electrical panel area there was a hazard of electric shock caused by peeled cables. The frequency score was 1, meaning that it might occur in certain unpredictable conditions. The severity score was 4, meaning that it would cause major injuries

requiring hospital treatment. The risk value was 4 (medium risk), meaning that it required attention and additional procedures. As an effort to control the hazard of the electrical panel area, PT X had employed an expert in electrical OSH whose job was to watch and inspect the electrical area. This was in accordance with the Minister of Manpower Regulation No. 12 of 2015 on the Electrical Occupational Safety and Health Chapter III Clause 6 Paragraph 3 which mentions that the person who conducts the maintenance is an expert in Electrical OSH. Other control measures such as replacing and isolating peeled cables, replacing damaged cable tray, and repairing corroded support cable tray which had been recommended were still in the list of additional controls and had not been executed (Lazuardi, 2022)

h. Production Area

In the production area, there was a hazard of being hit by building materials. This was because the building of the NPK factory was constructed with easily corroded materials and they might fall off anytime to hit the workers in the area. The frequency score was 3, meaning that it might happen in certain conditions. The severity/effect score was 5, meaning that it could result in fatalities and major loss. Control measures were then implemented by temporarily replacing the sidings with wire ties. The frequency score became 2 and effect/severity score 2. The risk value became 4 (medium risk), meaning that it required attention and additional procedures. Beside the hazard of being hit by building materials, there was a noise hazard caused by the crashing of balls inside the drying and cooling machines. The noise was heard all the time so that the frequency score was 5, meaning that it would always happen in every situation. The severity/effect score was 3, meaning that it required hospital treatment. Control measures were implemented by having the workers wear earplugs every time they enter the work area. This reduced the frequency score into 2, meaning that it would only happen in certain conditions but with low possibility. The effect/severity score was still 3. The risk value was 6 (medium risk), meaning that it would require special attention and additional procedures. The next was slipping hazard. This was due to the presence of hazard caused by raw materials such as clay and phosphate originating from the Diammonium phosphate (DAP) which has hygroscopic nature or easily absorbing water as one of its characteristics (Novita, 2021).

Because of this, the work area became slippery from the mud resulting from the spill of raw materials and the improperly handled dust. Every time the coating process area was covered with spills of raw materials so that every worker was at risk of slipping. As such, a score of 5 was given for the probability, whereas the severity due to the slipping was scored 3 meaning that it would result in injury with light loss. The risk value was 15 (extreme risk) without control. Control measures were then implemented by conducting weekly routine cleaning and application of rubber boots to minimize slipping hazard and lower the score into 1 meaning that it might happen in unpredictable conditions with a severity score of 2 meaning that it would cause light injury which would require first aid treatment. The risk value changed into 2 (low risk) meaning that it required monitoring measures to ensure that control measures be implemented properly. The Minister of Manpower and Transmigration Regulation No. 13 of 2011 on the maximum threshold and chemical factors in a work area Chapter II mentions that the maximum threshold of noise is 85 dB within 8 working hours. Noise beyond 85 dB within the same working hours requires control measures. This has been complied with by the NPK factory of PT X by applying a regulation on the obligation to wear earplugs for everyone entering the NPK factory. It was in accordance with the Minister of Manpower Regulation No. 8 of 2010 Clause 2 Paragraph 1 which requires the provision of PPE for the workers. The Law No. 1 of 1970 Chapter V regarding Coaching Clause 9 Paragraph 1 mentions that the management is required to conduct socialization of hazards in a workplace, provide personal protective equipment, and communicate safe work practices (work procedures, work instruction, posters, danger signages in a work area, etc) for the workers. As an effort to comply with the obligation, the management of PT X has implemented the

activities according to the Law No. 1 of 1970 Chapter 5 on Coaching (Guidance) Clause 9 Paragraph 1. This was proved with the implementation of control measures by providing personal protective equipment for the workers (UU, 1970)

i. Reject Process

In the reject process, there was a cutting hazard. It was because the workers should open bags containing rejected products. To do it fast, the workers used knives to tear the bags. The frequency score was 3, meaning that it might happen in certain conditions. The effect/severity score was 3, meaning that it could cause major injuries requiring hospital treatment. There has been no control measure for this hazard. Beside the cutting hazard, there was a dust exposure hazard resulting from the dispersion of the products and might be exposed to the workers in the reject product section. The frequency score was 5 since it would occur as long as there is a production process. The effect/severity score was 3, meaning that it would require hospital treatment. The risk value was 15 (extreme risk). Control measures were implemented by rotating the workers every 2 hours and having the workers wear masks. These decreased the frequency score to 3 and the effect/severity score to 2. The risk value became 6 (medium risk), meaning that it would require attention and additional procedures. The next was an ergonomic hazard. This was due to the bending work posture with repetitive movement which might cause complaints of back pain and muscle cramps. The frequency score was 5, meaning that it might happen in every condition. The severity score was 3, meaning that it required hospital treatment. Therefore, controls were implemented by rotating the workers every 2 hours to reduce the frequency score to 3 and the severity score to 2, meaning that it could be handled with first aid treatment. The risk value was 6 (medium risk), meaning that it required attention and additional procedures. According to the MSDS of urea fertilizer of PT X, the hazards caused by urea include skin irritation, eye irritation, and respiratory irritation (Puspitasari, 20190).

According to the Presidential Regulation No. 7 of 2019 on occupational diseases, one of the materials causing diseases due to chemical factors is phosphorus and its derivatives. Whereas, diammonium phosphate is one of the derivatives which is used in the production of NPK fertilizer. Therefore, hazards caused by this raw material should be controlled immediately. The NPK factory of PT X has implemented controls by establishing regulations requiring everyone entering the production area to wear a mask. This has been consistent with the Minister of Manpower Regulation No. 8 of 2010 on the Personal Protective Equipment Clause 2 Paragraph 1 which mentions that an employer/company is obliged to provide personal protective equipment. It is also reinforced with the Minister of Manpower Regulation No. 5 of 2018 Chapter II Clause 7 Paragraph 3 regarding control measures in the forms of engineering control and provision of PPE. The Minister of Manpower Regulation No. 5 of 2018 on the Occupational Safety and Health for Work Environment Part Five regarding Ergonomic Factors Clause 23 mentions that ergonomic factors may cause occupational diseases due to work practices, work positions, and work postures which do not conform the anthropometry of workers (Perpres, 2019)

4. Conclusion

The results of hazard identification using the HIRARC method on the NPK factory of PT X show that there were hazards of chemical dust exposure, slipping, hitting, being hit by iron balls, explosions, ergonomics, heat from the machines, being pinched by rotating equipment, electric current, noise, and being cut by sharp objects. Evaluation on the risk value using the HIRARC method on the production department of PT X shows that this department had the highest score, namely 15 under the extreme level for the hazard without controls consisting of chemical dust exposure, being pinched by rotating equipment, explosion, falling from height, ergonomics, and being hit by materials. Upon implementation of control measures, risk values decreased so that there were no more hazards in the extreme and high levels. The results of control measures using the HIRARC method were decided based on the highest risk value, namely the extreme level, where hazards should be given

preventive and control measures to avoid the workers from dangers. Control measures should be implemented continuously to minimize the risk value to the acceptable level. The control measures implemented by PT X have been in accordance with the Minister of Manpower Regulation No. 5 of 2018 on the Occupational Safety and Health for Work Environment Chapter 7 Clause 7 Paragraph 3 which mentions that the control of work environment should be implemented according to the control hierarchy consisting of elimination, substitution, engineering control, administration, and PPE application. The decrease in risk values of the total of 28 hazards started from the risks without controls, namely *extreme risk* 21 (75%), *high risk* 4 (14%), *medium risk* 3 (11%) of the total 28 hazards (100%). Upon implementation of controls, the values became *high risk* 3 (11%), *medium risk* (23%), *low risk* 2 (7%) of the total 28 hazards. In the list of additional controls, from 28 hazards there were 13 hazards which could be treated with additional controls. If the company succeeds in implementing additional controls, then the risk values can be reduced to *medium risk* 7 (54%), and *low risk* 6 (46%).

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