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Analysis of the Implementation of Hazard Identification, Risk Assessment and Risk Control (HIRARC) in the Work Environment Against Work Accidents (Case Study of PT XYZ)

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Abstract. *PT XYZ, an aluminum smelting industry with high temperatures, has faced many near misses and accidents. This study aims to improve risk evaluation by analyzing the effect of the implementation and understanding of HIRARC on work accidents through the work environment. Data were collected from 179 respondents in the production section using purposive sampling and analyzed using the structural equation modeling method. The research results show that the implementation of HIRARC has a significant effect on the work environment, while the understanding of HIRARC is not significant. HIRARC implementation also affects work accidents, while the understanding of HIRARC is not significant. The work environment also influences work accidents. HIRARC implementation has an indirect effect through the work environment as a mediating variable, while understanding HIRARC has no indirect effect through the work environment. The recommendations proposed include installing blowers or shady areas with drinking water stations, using PPE, developing easy-to-understand OSH regulations and procedures, as well as implementing regular training, monitoring, and evaluation.*

Keywords: *HIRARC; Work environment; Work accident; K3.*

I. INTRODUCTION

The International Labor Organization states that globally there are around 340 million victims due to work accidents each year, of which there are around 160 million victims of work-related diseases and around 2.3 million workers who di. Based on this , it shows that there are approx 6,300 casesdue to work accidents that caused a lot of losses or costs incurred directly or costs that were not comparable were incurred at a later date.

The reported number of work accidents in Indonesia also shows an increase every year. This is shown by the work-related accident data that occurred. In 2017 there were around 123 thousand cases of work-related accidents, meanwhile in 2018, there were around 173 thousand cases, while in 2019 it reached 116 thousand cases (Central Bureau of Statistics, 2019) . Work accidents that occur often cause health problems to safety problems such as fatigue, injury, death to material losses. This often occurs in various industries including the manufacturing industry.

There has also been an increase in the number of work accidents in several provinces in Indonesia, such as North Sumatra. Work-related accidents that occurred in the industry in North Sumatra in 2021 reached 1200 cases and in 2020 reached 13,000 cases (BPJS Ketenagakerjaan North Sumatra, 2021) . The causal factor is due to employers not fulfilling their obligations to protect workers by preparing work equipment and adequate security at the workplace, including providing orker protection in collaboration with health insurance.

This shows that there are about 20 cases of work accidents that occur every day in industries that have high risks and hazards. There are many types of mild to severe work accidents that occur every day, not all of which are reported correctly to follow up on prevention efforts (Ministry of Manpower, 2019) .

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PT XYZ which is an industry in North Sumatra engaged in the high temperature aluminum smelting industry. At this company there are many near miss and accident activities caused by workers' lack of understanding of potential hazards in the work environment, dehydration, fatigue, muscle cramps, being touched by hot objects, splashed with molten aluminum and workers who neglect personal safety or do not use PPE.

PT XYZ has implemented hazard identification with the HIRARC approach, but the reported accidents only show a decrease of 16.7%. This does not include accidents that are not reported in the annual report. Based on these data, it shows that HIRARC has not been implemented optimally. PT XYZ needs to improve the evaluation of the risk of work accidents so that employees can work optimally and the company is able to compete with competitors.

II. Research Method

Data collection techniques in this study were carried out by distribution of questionnaires. The data sampling technique was carried out by purposive sampling to respondents totaling 179 workers in the production section, namely the carbon, foundry, and reduction departments.

Meanwhile the data analysis technique uses the SEM method which consists of a measurement model, model accuracy test and structural analysis of the model using path analysis and using IBM SPSS AMOS 24 software.

III. Result and Discussion

Results

The measurement model or measurement model aims to find out how precisely the indicators are able to reflect the latent theoretical constructs. At this stage it is presented in Table 1.

Testing the accuracy of the model is the main goal in SEM, namely to find out how far the hypothesized model is right or matches the sample data. The model accuracy test is carried out partially on each construct presented in Figure 1 below.

Table 1. Measurement Model

Indicator	Variable	Loading Factor	AVE	CR
X1.4	HIRARC implementation	0.689	0.500	0.864
X1.3	HIRARC implementation	0.709		
X1.8	HIRARC implementation	0.803		
X1.10	HIRARC implementation	0.624		
X1.2	HIRARC implementation	0.693		
X1.12	HIRARC implementation	0.720		
X1.5	HIRARC implementation	0.579		
	Total	4,238		
X2.8	Understanding HIRARC	0.832	0.623	0.867
X2.5	Understanding HIRARC	0.882		
X2.3	Understanding HIRARC	0.764		
X2.1	Understanding HIRARC	0.662		
	Total	2,478		
Y1.4	Work environment	0.708	0.527	0.909
Y1.5	Work environment	0.744		
Y1.6	Work environment	0.751		
Y1.7	Work environment	0.722		
Y1.2	Work environment	0.780		
Y1.3	Work environment	0.733		
Y1.8	Work environment	0.718		
Y1.1	Work environment	0.771		
Y1.9	Work environment	0.711		
	Total	6,638		
Y2.8	Work accident	0.714	0.535	0.851
Y2.6	Work accident	0.787		
Y2.5	Work accident	0.717		
Y2.3	Work accident	0.714		
Y2.1	Work accident	0.708		
	Total	3,640		

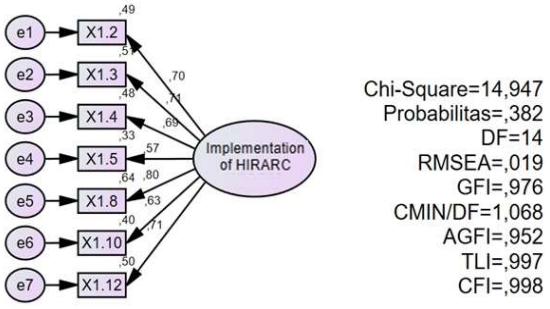

Figure 1. CFA Second Order Construct X1

Testing in Figure 1 CFA second order construct X 1 above shows that the model meets the critical and fit values. This can be seen from the chi-square value which is smaller than the critical value, namely 14.947 <23.685, with a probability (P) > 0.05 and several other criteria such as GFI, CMIN/DF, AGFI, TLI, and CFI have met the fit criteria.

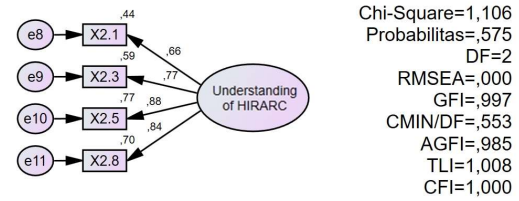

Figure 2. CFA Second Order Construct X_2

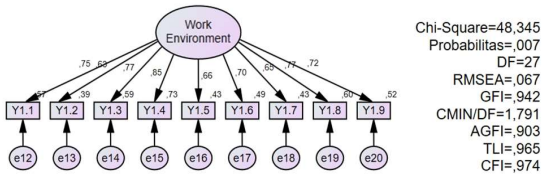

Figure 3. CFA Second Order Construct Y_1

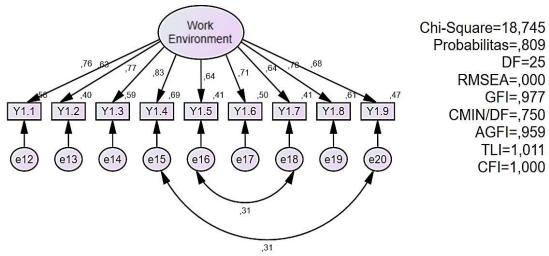

Figure 4. CFA Second Order Construct Y_1 Modification

Testing in Figure 2 CFA second order construct X 2 above shows that the model meets the critical and fit values. This can be seen from the chi-square value which is smaller than the critical value with probability (P) > 0.05 and several other criteria such as RMSEA, GFI, CMIN/DF, AGFI, TLI, and CFI have met the fit criteria.

In Figure 3, a dimensional test is carried out to see if there is a problem with model identification. Next, do a model feasibility test by looking at the problem of model identification on the MI covariance (modification indices). The suggested covariance will be connected based on the existing theory until the fit criteria are obtained.

Modification

Testing in Figure 4 CFA second order construct Y 1 shows that there is a covariance between e16 from the indicator (temperature) and e18 from the indicator (attitude). This shows that there is a correlation effect between temperatures that exceed the temperature threshold value and worker attitudes, causing the body's control mechanisms to no longer work properly which can ultimately have an impact on health performance and lead to heat stress (Mahawati et al., 2021).

Next, the covariance between e15 from the indicator (work equipment) is connected with e20 from the indicator (responsibility). Where the correct use of safe or safety work equipment, including PPE, is the responsibility of the worker.

This is due to the fact that the provision of PPE is generally preferred because it can be used immediately, whereas elimination or other alternatives for controlling hazards will take longer time even though it has a greater control impact (Mahawati et al., 2021).

Testing on the second order CFA construct Y1 above shows that the model meets the critical and fit values. This can be seen from the chi-square value which is smaller than the critical value, namely 18.745 <37.652, with a probability (P) > 0.05 and several other criteria such as RMSEA, GFI, CMIN/DF, AGFI, TLI, and CFI have met the criteria fit.

The test in Figure 5 CFA second order construct Y_2 above shows that the model meets

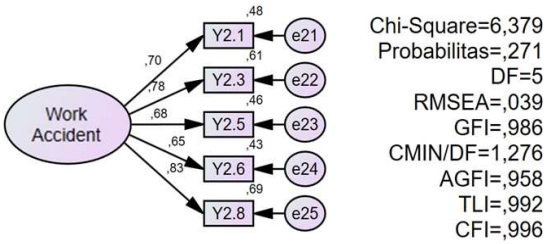

Figure 1. CFA Second Order Construct Y_2

the critical and fit values. This can be seen from the chi-square value, which is smaller than the critical value, namely 6.379 <11.070, with a probability (P) > 0.05 and several other criteria such as GFI, CMIN/DF, AGFI, TLI, and CFI already meet the criteria. Even though the RMSEA value in the model is not appropriate, if more than three criteria meet the fit criteria then the model can be accepted (Ghozali, 2017).

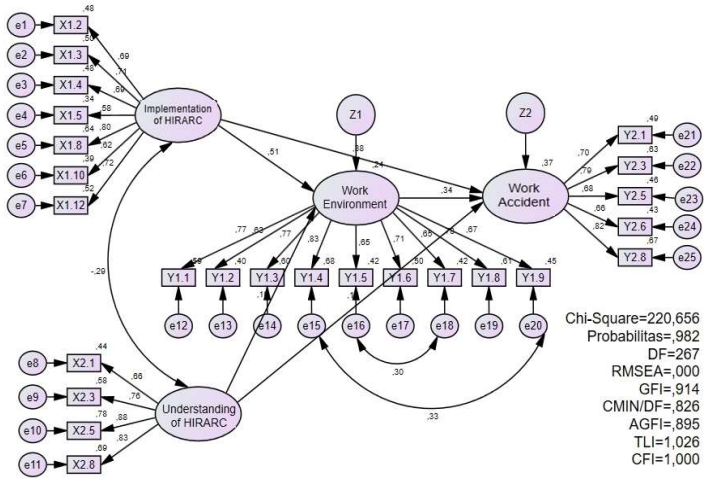

Figure 5. CFA Second Order Full Model

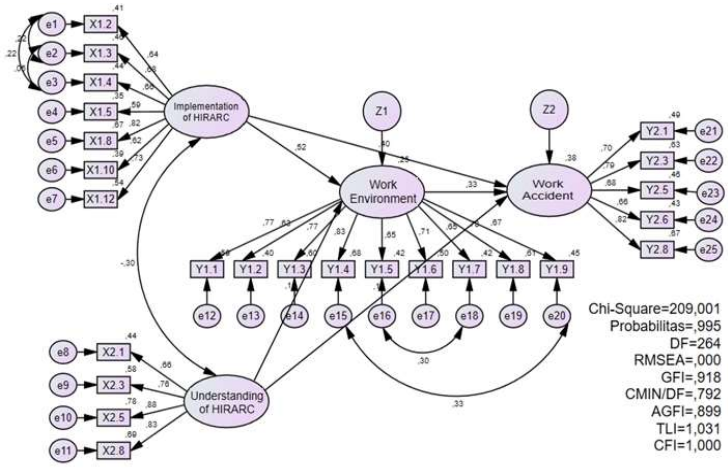

Figure 6. CFA Second Order Full Model Modification

After obtaining a fit construct model of each latent variable, the next step is to combine all of the latent variables shown in Figure 6.

The purpose of merging the four constructs is to obtain a full fit model, which later estimates from the fit model can be used for path analysis coefficients that divide the relationship between exogenous and endogenous variables into direct effects and indirect effects.

The next stage is to test the feasibility of the model by looking at the problem of model identification on the MI covariance (modification indices). The three suggested covariances consist of e1, e2 and e3 which will be combined and presented in Figure 7.

The covariance between the e3 of the indicator (environmental hazard) is related to the e1 of the indicator (health hazard). Where a good work environment has a good relationship or relationship to health, because the work environment is a hazard factor that can cause health problems and work accidents (Dewi, 2012).

Meanwhile the covariance e3 of the indicator (environmental hazard) is linked to the e2 of the indicator (safety hazard). A dangerous work environment is closely related to the dangers of worker safety, because a work environment that does not meet ideal standards can interfere with optimal work activities (Dewi, 2012).

The three errors are indicators of health hazards (e1), safety hazards (e2), and work

Table 1. Full Model Regression Coefficient

Variable Relations	Estimates	SE	CR	P
HIRARC Implementation -> Work Environment	0.762	0.150	5,092	0.000
HIRARC Understanding -> Work Environment	0.102	0.076	1.355	0.175
HIRARC Implementation -> Work Accidents	0.508	0.135	3,780	0.000
Understanding HIRARC -> Work Accidents	0.124	0.063	1,956	0.050
Work environment -> Work Accident	0.284	0.079	3,575	0.000

Table 2. Indirect Effects

Track	Estimates	SE	CR
IH -> LK -> KK	0.216	0.073	2,936
PH -> LK -> KK	0.029	0.023	1,260

Table 3. Total Effect

	Environment Work	Work accident
HIRARC implementation	0.762	0.725
Understanding HIRARC	0.102	0.153
Work environment	0.000	0.284
Work accident	0.000	0.000

environment hazards (e3) which are interrelated, therefore workers are expected to be able to identify all three to avoid the risks that may arise.

After covariance between errors in the four constructs above. The chi-squares result of 209.001 is far below the critical value of 302.898 and the probability of 0.995 is also far above the significance value of 0.005, so it can be concluded that the model meets the fit criteria.

This can also be seen from the other fit criteria, namely RMSEA, GFI, CMIN/DF, TLI, and CFI, which also meet all the recommended requirements. Although the AGFI value is still less than 0.001 to meet the fit criteria, the modified full model is acceptable because it meets more than three fit criteria. Then the regression coefficient of the full model is obtained which is presented in Table 2.

After knowing the value of the direct effect of each variable based on a fit model. Then it can be seen the indirect effect on the output of data processing in SEM AMOS 24 which is summarized in Table 3. Indirect effects through the HIRARC Implementation (IH) and HIRARC Understanding (PH) on Work Accidents (KK) through the Work Environment (KK).

The two tables above show the variables that have a significant direct effect, where the $P_{value} < \alpha$ 0.05. The estimated value shows the direction, if it is positive, then the direction of the relationship between these variables is positive (directly proportional) and the direction will be inversely proportional if the direction of the relationship is negative.

Apart from these two values, the hypothesis can be accepted based on the critical ratio value compared to the value of $t_{table} = t_{0.05;\ 179} = 1.973$, which is said to be significant if the CR value is > 1.973. Furthermore, the structural equation and the indirect effect output are depicted in Figure 6.

Based on the path analysis above, we divide

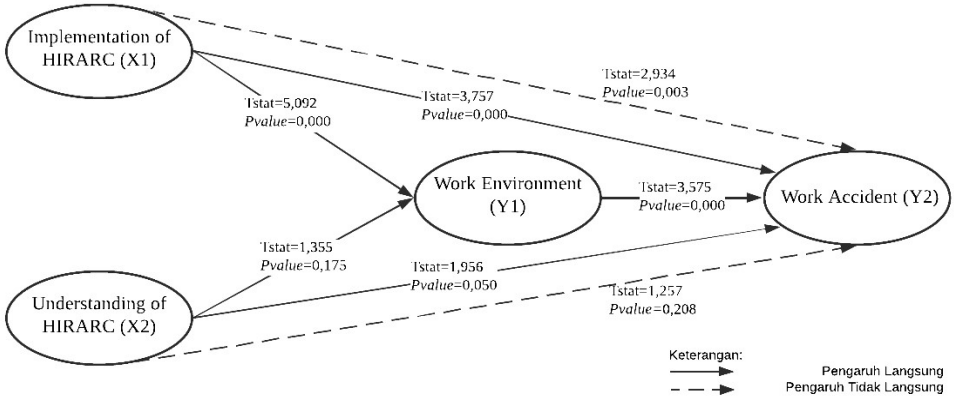

Figure 7. Path Analysis Coefficient Model

the relationship between exogenous and endogenous variables into direct effects and indirect effects . The direct effect is indicated by a direct arrow from the exogenous variable (X) to the endogenous variable (Y).

Furthermore, the total effect is obtained by adding up the estimated value of the direct and indirect effects. The total effect or total effect is presented in Table 4.

Based on the total effect, it shows that the implementation of HIRARC has the greatest total effect effect (0.762) than the total effect of understanding HIRARC (0.102) on the work environment. Meanwhile the results of calculating the total effect of HIRARC implementation have the greatest total effect (0.725), than the total effect of the work environment (0.284) and the total effect of understanding HIRARC (0.153) on work accidents.

Square value known as the coefficient of determination which aims to measure how well the SEM model can explain variations in endogenous variables. The following is the simultaneous R- square obtained based on the AMOS output and is presented in Table 5.

Table 5. R-square value

Squared Multiple Correlations (R^2)	Estimates	
	X_1	X_2
Work Environment (Y1)	0.247	
Work Accident (Y2)	0.381	

R-square value. The results obtained above show a value of 0.247 which indicates that 25% of the variation in the work environment variable can be explained by the implementation of HIRARC and understanding of HIRARC. Meanwhile, the R- square result of 0.381 indicates that 38% of the variation in the work accident variable can be explained by the implementation of HIRARC and understanding of HIRARC.

The Effect of HIRARC Implementation on the Work Environment. Testing the hypothesis above has a CR value or $t_{count} > t_{table}$ resulting in 5.092 > 1.973 and a $P_{value\ of}$ 0.000 <0.05. It can be concluded that there is a significant direct effect of the HIRARC implementation variable on the work environment. This shows that the application of HIRARC is a closely related interaction between workers and the work environment in hazard identification, risk assessment, to control on the production floor.

The more proficient workers are in implementing HIRARC, the more proficient they are in overcoming potential hazards in the work environment or known as environmental mitigation, which is an effort to prevent negative impacts that are expected to occur.

The Effect of Understanding HIRARC on the Work Environment. The hypothesis testing above has a CR value of 1.355 <1.973 and a P_{value} 0.175 > 0.05. It was concluded that there is no significant effect between the understanding of HIRARC on the work environment. Several factors have caused this to occur , such as a lack of training and outreach regarding HIRARC to employees, lack of management support and active role in implementing HIRARC. or maybe the work environment is sufficient so that the understanding of HIRARC does not have a significant effect.

Effect of HIRARC Implementation on Work Accidents. The hypothesis testing above has a value of 3.780 > 1.973 and a P_{value} 0.000 < 0.05. It can be concluded that there is a significant influence between the implementation of HIRARC on work accidents. Based on the results of the hypothesis testing that has been carried out, it shows that the implementation of HIRARC applied by PT XYZ workers has been said to be good.

Both in terms of hazard identification, risk assessment and control of work accident prevention. So that workers have the ability to prevent work accidents, namely the ability to avoid unsafe conditions and behavior by implementing OHS policies, implementing safety training, and being committed to OHS.

The Effect of Understanding HIRARC on Work Accidents. The results of testing the hypothesis above have a CR value of 1.956 <1.973 and a P_{value} 0.050 > 0.05. Based on the results obtained, it was concluded that there was no significant effect between the understanding of HIRARC on work accidents at PT XYZ. The absence of a significant effect can also be seen

from the respondent's score on the lowest statement item indicating that PT XYZ workers are still not able to understand the risks received in the event of a near miss (almost happened an accident) to incident (work accident happened) .

Thus, it can be concluded that it is necessary to make efforts to increase the understanding of HIRARC among PT XYZ workers in order to better understand the risks that may occur and avoid work accidents in the future.

The Effect of the Work Environment on Work Accidents. The results of testing the hypothesis above have a CR value of 3.575 > 1.973 and a P_{value} 0.000 < 0.05. So it can be concluded that there is a significant influence between work environment variables on work accidents. This is also supported by the loading value the biggest factor produced by the work equipment indicator, the value of 0.826 indicates the work environment, one of which consists of work equipment and tools, is sufficient and complete. Complete work equipment supports the implementation of work properly, so as to increase worker awareness regarding work accidents.

The Indirect Effect of HIRARC Implementation on Work Accidents Through the Work Environment as a Mediating Variable. The results of testing the hypothesis above has a CR value of 2.934 > 1.973. So it can be concluded that there is a significant indirect effect between the implementation of HIRARC on work accidents through the work environment as a mediating variable . This effect is indirect because the implementation of HIRARC does not directly affect work accidents, but affects the work environment which then affects work accidents. Therefore, it can be concluded that the implementation of HIRARC can improve occupational safety and health by improving the work environment as a mediating variable.

The Indirect Effect of HIRARC Understanding on Work Accidents Through the Work Environment as a Mediating Variable. The results of testing the hypothesis above has a CR value of 1.260 <1.973. Then it can be concluded HIRARC understanding does not have a significant indirect effect on work accidents through the work environment as a mediating variable. This shows that there is no relationship or interaction between the understanding of HIRARC and the work environment which has an impact on work accidents.

On the other hand, it is possible that even though an understanding of HIRARC can increase awareness about occupational safety and health and improve the work environment, it does not significantly affect the rate of work accidents. The analysis above shows that there is no relationship or interaction between the understanding of HIRARC and the work environment which has an impact on work accidents.

Total Influence Analysis. The total effect is obtained by adding up the direct and indirect effects presented in Table 4.25 output total effects. Based on the results of the total effect presented, the total effect of HIRARC implementation and understanding of HIRARC on the work environment shows that HIRARC implementation has the greatest total effect (0.762) of the total effect of HIRARC implementation (0.102).

Based on this analysis, it shows that the implementation of HIRARC at PT XYZ has a close relationship with the work environment, in contrast to the understanding of HIRARC which only focuses on understanding the scope of OSH procedures and does not focus on implementing the hazard identification itself.

Recommendation. The R-square results show that the application and understanding of HIRARC has an influence of 25% on the work environment and 38% on work accidents. Therefore, companies are advised to add the use of K3 methods which are suitable for metal industries that operate at high temperatures such as:

Job Safety Analysis (JSA) to identify hazards and evaluate risks associated with certain tasks in the workplace, Total Productive Maintenance (TPM) method for maintaining machines and equipment that must be maintained properly so as not to fail which can cause accidents and losses for the company in the metal industry operating at high temperatures and Behavior-Based Safety (BBS) methods that teach employee

behavior changes to be safer at work (Sharman & Kurman, 2020) .

In addition to some of the above, recommendations are also given based on the factor loading value of the manifest variable in the CFA measurement between the constructs or variables as follows. First, according to cases that often occur at PT XYZ, workers are often exposed to hot objects or splashes of melted aluminum.

The recommendation given is that PT XYZ needs to strengthen control at the source to reduce the work risk caused by being exposed to hot objects by using one of them with carry out administrative control or even control directly at the source, namely elimination, such as changing the machine or reducing the amount of liquid aluminum per production.

According to Nugroho et al (2020) elimination in controlling the risk of work accidents has an important role in jobs that can follow metal casting guidelines from the American Foundry Society (AFS) which can provide information and practical advice on implementing risk control strategies to eliminate or reduce the danger of exposure to hot objects and molten aluminum splashes at work .

Second, at PT XYZ workers often experience cramps and fatigue due to the intensity of exposure to heat stress over a long period of time. Recommendations given include accurate risk assessment , source control , use of personal protective equipment (PPE) , training and outreach , monitoring and evaluation (Jacklitsch et al., 2016) . Accurate risk assessment related to fatigue due to heat stress, such as considering the intensity of exposure, duration, and other environmental factors that can affect fatigue such as holding work rotations between workers for drinking breaks (1-2 minutes) every 20-30 minutes .

Implement controls at the source to reduce the risk of heat exhaustion, such as increasing air circulation, lowering room temperature, using ventilation and cooling or blowers , or reducing the workload on workers. According to (Supriono, 2020) heat exhaustion which can cause heat stress can be overcome with the urgency of making drinking water stations to prevent dehydration and shelter areas for short breaks.

Third, recommendations based on ISO 31000:2018 - Risk management - Guidelines are as follows: Re-evaluate the company's risk management program to ensure that the scope constructs (areas or aspects of the work environment that are the focus of risk identification and evaluation) . Companies need to apply a more structured and comprehensive approach in identifying and evaluating risks related to the scope of what can be achieved.

By using risk management framework guidelines such as ISO 31000, conduct training and development focused on the scope construct of increasing understanding of HIRARC, and prioritizing the most effective controls in reducing risk.

Fourth, in several cases at PT XYZ, workers were often exposed to splashes of molten aluminum arising from the smelting furnace which resulted in explosions of molten aluminum pouring into the tundish . Splashes of molten aluminum can be avoided by wearing heat-resistant clothing, but in reality, the workforce is reluctant to wear heat-resistant clothing because it is uncomfortable and restricts movement.

Control efforts are carried out in protecting the workforce from hazards, one of which is by providing education regarding the dangers that may arise from splashing molten aluminum, education on the use of PPE, and imposing sanctions if not using PPE, such as heat-resistant safety clothing (Supriono, 2020) .

IV. CONCLUSION

The results of data analysis, hypothesis testing and discussion that have been carried out, the following conclusions are obtained .

1. The HIRARC implementation variables affect the work environment, from a CR value of 5.092 > 1.973 and a P_{value} of 0.000 <0.05 . HIRARC implementation is a closely related interaction between workers and the work environment . The more proficient workers are in implementing HIRARC, the more proficient environmental mitigation efforts will be in

preventing negative impacts that are expected to occur.

2. Meanwhile the HIRARC understanding variable has no effect on the work environment, from a value of 1.355 <1.973 and P $_{value}$ 0.175 > 0.05 . This is caused by several factors, such as lack of training and outreach, lack of support and active role of management, or perhaps an adequate work environment.
3. R- square value shows that 2.5 % of the work environment variables can be explained by the HIRARC implementation and understanding variables while the remaining 75.3 % of the work environment is influenced by other variables not examined.
4. The HIRARC implementation variable affects work accidents, from a CR value of 3.780 > 1.973 and P $_{value}$ 0.000 < 0.05 . The HIRARC implementation applied by PT XYZ workers has been said to be quite good because workers have the ability to prevent work accidents such as avoiding unsafe conditions and behavior.
5. Meanwhile it was concluded that there was no effect of understanding HIRARC on work accidents at PT XYZ, from a CR value of 1.956 < 1.973 and P $_{value}$ 0.050 > 0.05. The lowest respondent's score on the statement item shows that PT XYZ workers are still not able to understand the risks involved in the event of a near miss (almost an accident) until an incident (work accident) occurs .
6. Work environment variables affect work accidents, from a CR value of 3.575 > 1.973 and P $_{value}$ 0.000 < 0.05 . This shows that the work environment, one of which consists of work equipment and tools, is sufficient and complete to support the implementation of work properly, so as to increase worker awareness regarding work accidents.
7. R- square value shows that 38% of work accident variables can be explained by HIRARC implementation variables, understanding HIRARC as well as work environment and there is influence between these variables. While the remaining 62 % of work accidents are influenced by other variables.
8. The HIRARC implementation variable has an indirect effect on work accidents through the work environment as a mediating variable, from the resulting CR value of 2.93 6 > 1,973 . The more skilled workers apply HIRARC in aligning themselves with the work environment, the less likely work accidents will occur.
9. Meanwhile the HIRARC understanding variable has no indirect effect on work accidents through the work environment as a mediating variable, from the resulting CR value 1.2 60 < 1.973 . This shows that there is no relationship or interaction between the understanding of HIRARC and the work environment which has an impact on work accidents.
10. The recommendations given based on the value of the loading factor are as follows. First, cramps and heat exhaustion are treated by installing a blower or creating a shady area with a drinking water station to take a break every 30 minutes. Second, being exposed to hot aluminum splashes is treated by using PPE, especially heat-resistant clothes. Third, security for workers who ignore working safely is handled by work regulations and sanctions, or compiling K3 regulations and procedures in terms that are not too complicated so that they are easy to understand and apply.
11. Then increase the commitment of management and workers related to safety culture with safety training , monitoring and evaluation. In addition to the several recommendations above, companies which are metal industries that operate at high temperatures can also add the use of suitable K3 methods such as Job Safety Analysis (JSA), Total Productive Maintenance (TPM), and Behavior-Based Safety (BBS) to minimize the risk of accidents. and losses for the company.

REFERENCES

Ardila, AR, Lubis, HS, & Mahyuni, EL (2014). Analysis of Work Accident Investigation Results at Inalum Smelting Plant (ISP). *Journal of Environmental Health and Occupational Safety, 4* (3).

North Sumatra Employment BPJS. (2021). *Number of Work Accidents for the 2020 Period - 2021*. bpjsketenagakerjaan.go.id .

Dewi, A. (2012). *Basics of Occupational Safety and Health* . In UPT Publishing UNEJ. Goshen Publishing.

Dosh. (2019). *Guidelines for Hazard Identification , Risk Assessment and Risk Control (HIRARC)*. Department of Occupational Safety and Health, Ministry of Human Resources.

Ghozali, I. (2017). Structural Equation Model Concepts and Applications with the Amos 24 Update Bayesian SEM (VII) Program. Diponegoro University.

Hariyadi, H. (2014). Analysis of the Linkages Between Work Environment, Safety and Health on Work Productivity with the Structural Equation Modeling Method (Case Study : PT. Media Karya Sentosa Gresik). Matrix Journal , XV (1), 55–65. https://doi.org/10.30587/matrik.v15i1 .

International Labor Organization. (2018). World Statistics: The enormous burden of poor working conditions . ilo.org .

Ministry of Labor . (2019). Give Severe Penalties to K3 Violators . kemnaker.go.id .

Kline, RB (2016). Principles And Practice Of Structural Equation Modeling . Guilford Publications.

Kurniawan, M. ., & Wibowo, A. (2020). Risk Management Assessment Using Structural Equation Modeling (SEM) in the Indonesian Construction Industry. Journal of Construction in Developing Countries , 25 (1), 1–20.

Kustono, D., Solichin, Martiningsih, A. (2015). Occupational Safety and Health . Aditya Media Publishing.

Mahawati, E., Fitriyatinur, Q., Yanti, CA, Rahayu, PP, Aprilliani, C., Hartini, MCE, Sari, M., Marzuki, I., Jamaludin, ES, & Susilawaty, A. (2021). Occupational Safety and Industrial Environmental Health. In Our Writing Foundation .

Nuraini, F., Kamilah, S., & Fauziyah, A. (2021). Analysis of Work Safety Factors using Structural Equation Modeling (SEM) Approach on Manufacturing Companies in Indonesia. Journal of Physics: Conference Series , 1892(1) , 12–79.

Rahayuningsih, S. (2019). Identification of Implementation and Understanding of Occupational Health and Safety Using the Hazard And Operability Study (HAZOP) Method in Eka Jaya UMKM. UNIQUE TEAK : Scientific Journal of Industrial Engineering and Management , 2 (1), 24. https://doi.org/10.30737/jatiunik.v2i1.274 .

Saleh, LM, Cahyadi, AT, & Syria. (2019). The Influence of Occupational Safety and Health on Fatigue, Accidents and Employee Productivity at PT. Angkasa Pura I. Journal of Management and Visionida Business , 2 (1).

Santoso, S. (2021). Structural Equation Modeling (SEM) Analysis Using AMOS 26 (1 ed.). Jakarta: Elex Media Komputindo, 2021.

Setiawan, RA, & Nurcahyo, I. (2020). The Effect of HIRARC and Work Environment on Occupational Accidents . Journal of Occupational Safety and Health , 10 (2), 40–45 .

Sharma, M., & Kumar, P. (2020). Safety Management in Thermal Power Plants. Hershey : IGI Global.

Standardization, IO for. (2018). ISO 31000:2018 - Risk management - Guidelines . International Organization for Standardization.

Sugiyono. (2016). Quantitative, Qualitative and R&D Research Methodology. In CV Alfabeta .

Sujoso, A. (2012). Basics of Occupational Health and Safety. In UPT Publishing UNEJ .

Sulistyawati, I., Sukoco, A., & Ali, M. (2019). Analysis of Occupational Safety and Health Factors on Employee Performance with the Structural Equation Modeling Approach (Case Study at PT. Garam). Journal of Management and Agribusiness , 16(2) , 123–131. https://doi.org/10.17358/jma.16.2.123

Sutrisno, A., Rahmat, A., & Kadir, Y. (2019). Analysis of the Effectiveness of the Implementation of Occupational Safety and Health (K3) Programs in Construction Projects (Case Study: PT Indorama Jatiluhur Purwakarta Textile Factory Project). Techno Journal .

Tarwaka. (2014). Occupational Safety and Health : Management and Implementation of K3 in the Workplace (Edition: II). Surakarta : Hope Press.