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Analysis of Work Accident Risk in Welding Process for Pipe Repair on Utility Boat PT LSM

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KEYWORDS
Health
Safety
Hazard
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ABSTRACT – PT LSM is a shipping company committed to focusing on providing integrated maritime services to support the oil & gas industry, PT LSM has a variety of offshore vessels to support these activities. LSM's shipping area is a rig area, where the area has a high level of danger and risk, therefore an adequate ship is needed both in crew and equipment on board. Especially in the piping system on board, if a leak occurs it can cause fatal things such as engine damage to an explosion and can cause work accidents such as fire and death. To minimize work accidents, risk hazard identification and risk control are made in each job, especially in piping work, namely pipe welding using the HIRADC method. This study used a descriptive qualitative method, in which the authors conducted field observations, interviews, and distributed questionnaires. The results of risk hazard identification, risk assessment and risk control will be entered in the HIRADC (Hazard Identification, Risk Assessment, and Determining Control) table. The conclusion of this study is that 43 hazards and 47 risks have been identified in pipe welding work. In the initial control, the low risk level was 42 risks (89.36%), the medium risk level was 5 risks (10.63%), and the high-risk level was 0 risks (0%). After further control of the identified risks, the risk level of medium risk (10.63%) has changed to low risk, so that all risk levels of the LSM Provider's ship pipe welding work have changed to a low risk level with a total of 47 risks (100%)). The controls used in pipe welding work are substitution, administration, and personal protective equipment (PPE).

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INTRODUCTION

Utility boat (UB) is a type of multifunctional ship for transporting supplies to and from offshore oil platforms. There has been a lot of research related to utility boats or offshore service vessel. One of which is research on Business-process management in high-turbulence environments: the case of the offshore service vessel industry [3]. Working in the shipping industry sector has many occupational risks that can cause work accidents if the work is not carried out in accordance with existing procedures. To prevent work accidents, it must be done continuous maintenance on the operated ship is routine or periodic, with established internal and external procedures [1]. The piping system plays an important role in public services on ships. Because without a piping system, the pump as a tool for moving fluids from one place to another cannot flow or move the fluid [2]. Pipelines are the most important way to transport large amounts of dangerous substances as oil and gas, through long distances, due to their advantages in terms of safety and low cost. However, failures and leaks in pipelines may happen and sometimes they generate catastrophic consequences [3]. One of the causes of problems with pipes on ships is caused by the issue of axial forces in pipelines mounted along ship open decks, resulting from ship hull deformations in waves [4]. So it is necessary to repair the pipes on the ship, one of which is by welding. Pipeline welding is one of the key technologies in ensuring the ship overall manufacture quality [5]. Welding process is a hazardous activity on board ship. Potential safety hazards associated with arc welding include arc radiation, air contamination, electrical. The stability of the welding process is very sensitive to the main welding parameters such as current, voltage, welding speed, shielding gas and arc length shock, fire and explosion, compressed gases, and other hazards [6]. These processes are fraught with hazards of respiratory irritation and systemic poisoning from exposure to toxic fumes and particles along with thermal burns from welding [7]. The management of risk through engineering controls and/or respiratory protection should account for the characteristics of welding methods, fillers, and base metals [8].

Occupational hazards and risks are closely related to work activities that cause potential minor injuries to death for workers. These hazards include slipping, falling, being scratched by materials, electric shocks, burns and others [9].

Several previous studies that examined this matter, such as research by Tambuan, Willy et al. (2019), lack of awareness and concern for K3 resulted in work risks, namely accidents that still occur in welding activities carried out in tugboat maintenance, such as being hit by welding sparks, slipping, touching hot iron which causes injury to workers [10]. Risk control efforts that can be carried out include controlling PPE, Administrative Control, and Engineering Control [9]. Other studies also discuss the Risk assessment of oil drilling rig welded pipe based on structural integrity and life estimation [11]. Risk analysis should always aim at the possibility of avoiding or minimizing the factor that caused the hazard and should be performed by persons who have practical knowledge of the process [12].

Table 1. Severity Level

Weight	Criteria	Definition	Possibility of Returning to Work	Material Loss
1	Not Significant	Shock, discomfort, fatigue, eye irritation	The victim can immediately return to work	Rp 0, - Rp 100.000
2	Minor	Victims require adequate first aid treatment. superficial skin wounds, bruises, scratches, headaches, mild shortness of breath, back pain	The victim needs to rest for about 1 hour	Rp 100,000 – Rp 20.000.000
3	Moderate	Victims require outpatient care, deep scratches, minor burns, sprains, asthma	The victim cannot work on the day of the incident or on weekdays	Rp 20.000.000 – Rp 100.000.000
4	Major	Victims require hospitalization, severe burns, high-voltage electric shock, concussion, fractures, serious injuries		Rp 100.000.000 – Rp 500.000.000
5	Extreme	Amputation, loss of limbs, cancer, death permanent disability, instant deafness due to ruptured eardrums	The victim must be hospitalized.	>Rp 500.000.000

Table 2. Level of Probability of Risk Occurrence

Weight	Criteria	Description
A	**(NEVER)** Risk never occurs	Occurs in abnormal conditions/natural disasters/emergencies/once a year
B	**(RARELY)** Risk rarely occurs every time an activity is performed	Occurs about once a month
C	**(SELDOM)** Risk sometimes occurs every time an activity is performed	Occurs about once a week
D	**(OFTEN)** Risk often occurs every time an activity is performed	Occurs every day
E	**(ALWAYS)** Risk will occur every time an activity is performed	Frequency occurs more than 3 times a day

Table 3. Risk Assessment Matrix

Severity Level (S)	Risk Probability (P)				
	A (Never)	B (Rarely)	C (Seldom)	D (Often)	E (Always)
5 (Extreme)	5A	5B	5C	5D	5E
4 (Major)	4A	4B	4C	4D	4E
3 (Moderate)	3A	3B	3C	3D	3E
2 (Minor)	2A	2B	2C	2D	2E
1 (Not Significant)	1A	1B	1C	1D	1E

Table 4. Risk Level Assessment Classification

Level	Risi
H = 3E, 4D, 4E, 5C, 5D, 5E	*High Risk*
M = 1E, 2D, 2E, 3C, 3D, 4B, 4C, 5A, 5B	*Medium Risk*
L = 1A, 1B, 1C, 1D, 2A, 2B, 2C, 3A, 3B, 4A	*Low Risk*

Table 5. Risk Assessment in the Process of "Iron Pipe Cutting" Activities

Detail of Activities	Hazard Description	Risk	Current control	Condition (R/NR/E)	Regulation	Initial Risk Value		
						S	P	R
Preparation of pipe cutting equipment	Manual Handling	Spinal cord injury	Carrying out proper handling, manually should not weigh more than 20kg/person	Routine	Yes	3	B	3B
	Manual lifting	Muscle injury	Performing proper lifting	Routine	Yes	3	C	3C
	Welding material Pressure tubes (oxygen tubes, acetylene/LPG)	Deep laceration	Using welding gloves	Routine	Yes	3	B	3B
Pipe cutting using a cutting torch	Welding material Pressure tubes (oxygen tubes, acetylene/LPG)	Death, Injury to limbs	Place the tube in a safe place, tie it so it doesn't fall	Routine	Yes	5	A	5A
	Welding hose (for oxygen, acetylene/LPG)	Respiratory disorders	Using a good regulator & hose (no leaks)	Routine	Yes	3	B	3B
	Welding steam	Eye irritation	Using a welding face shield/safety goggles	Routine	Yes	1	B	1B
	Welding smoke	Respiratory disorders	Using a welding face shield/mask	Routine	Yes	2	A	2A
	Welding flame	Burns	Using appropriate PPE for welding work (safety helmet, welding face shield, coverall, welding gloves, safety shoes)	Routine	yes	3	A	3A
Tidying up iron pipe cutting equipment	Manual handling	Spinal cord injury	Carrying out proper handling, lifting goods manually should not weigh more than 20kg/person	Routine	Yes	3	B	3B
	Manual lifting	Muscle injury	Performing lifting properly	Routine	Yes	3	C	3C
	Welding material residue	Deep laceration	Using welding gloves	Routine	Yes	3	B	3B

Table 6. Risk Assessment Matrix for Initial Control in the Process of "Iron Pipe Cutting" Activities

Severity Level (S)	Risk Probability (P)				
	A (Never)	B (Rarely)	C (Seldom)	D (Often)	E (Always)
5 (Extreme)	Pipe cutting: Pressure tube	5B	5C	5D	5E
4 (Major)	4A	4B	4C	4D	4E
3 (Moderate)	Pipe cutting: Welding flame	Equipment preparation: Manual handling, welding material Pipe cutting: Welding hose Equipment tidying: Manual handling, remaining welding material	Equipment preparation: Manual lifting Setting up equipment: Manual lifting	3C	3D
2 (Minor)	Pipe cutting: Welding fumes	2B	2C	2D	2E
1 (Not Significant)	1A	Pipe cutting: Welding hot steam	1C	1D	1E

The HIRARC method allows the identification of various potential hazards that may be associated with an activity or work environment. This approach involves data collection, situational analysis, and determining mitigation steps [13]. The developed risk assessment model is the combination of the probability of failure and the consequences of failure [14]. Ship repair activities contain many risks, one of which is the Occupational Safety and Health (K3) aspect. Control is carried out through risk management [15]. This article will discuss research related to the analysis of work accident risk in welding process for pipe repair on utility boat PT LSM In order to identify the hazards and risks of work accidents during pipe welding work, and how to determine their control using the HIRADC method.

Table 7. Risk Assessment in the Process of "Welding Using Electric Welding"

Detail of Activties	Hazard Description	Risk	Current control	Condition (R/NR/E)	Regulation	Initial Risk Value		
						S	P	R
Preparation of electric welding equipment	Manual handling	Spinal injury	Carry out proper handling, lifting goods manually should not weigh more than 20kg/person	Routine	Yes	3	B	3B
	Manual lifting for materials	Spinal injury	Doing lifting correctly	Routine	Yes	3	C	3C
	Sharp corners	Scratches/wounds	Recognize and avoid sharp corners on materials & work equipment, use welding gloves	Routine	Yes	3	B	3B
	Dust	Respiratory disorders	Using a welding face shield/mask	Routine	Yes	2	A	2A
	Non-ergonomic body position	Sprains	Doing work with the appropriate body position	Routine	Yes	3	A	3A
	Electricity	Electric shock from generator	Using cables of the appropriate size, filling out the work permit form checklist before doing hot work (No. Doc. F/LS-QHSE/28)	Routine	Yes	4	A	4A
Welding using electric welding	Welding heat	Skin irritation	Using coveralls and welding gloves	Routine	Yes	2	A	2A
	UV radiation	Visual disturbances	Using a welding face shield	Routine	Yes	1	A	1A
	Non-ergonomic body position	Sprain	Do the work with the appropriate body position	Routine	Yes	3	A	3A
	Electricity	Electric shock from generator	Using cables of the appropriate size, filling out the work permit form checklist before carrying out hot work (No. Doc. F/LS-QHSE/28)	Routine	Yes	4	A	4A
		Fire	Keep flammable materials away from the welding area, provide dry powder type APAR in the work area.	Routine	Yes	4	A	4A
	Welding smoke	Respiratory disorders	Using a welding face shield/mask	Routine	Yes	2	A	2A
	Welding flame	Burns	Using complete PPE according to welding work standards	Routine	Yes	3	A	3A
		Fire	Keep flammable materials away from the welding area, provide dry powder type APAR in the work area.	Routine	Yes	4	A	4A
Tidying up welding equipment	Manual handling of materials	Spinal cord injury	Carry out manual handling properly, goods ≥ 20kg are not allowed manually	Routine	Yes	3	B	3B
	Manual lifting	Muscle injury	Perform manual lifting correctly	Routine	Yes	3	C	3C
	Welding material residue	Deep laceration	Use welding gloves	Routine	Yes	3	B	3B
	Non-ergonomic body position	Sprain	Perform work with the correct body position	Routine	Yes	3	A	3A
	Electricity	High voltage electric shock	Ensure the electrical cable is disconnected	Routine	Yes	4	A	4A

METHOD

The research method used is the HIRADC (Hazard Identification and Risk Control) method. Identification of hazards and risks of pipe repair work is carried out by conducting observations and interviews with employees related to this work. After the identification is known, a risk assessment is then carried out. Risk analysis is carried out based on considerations of risk sources, risk consequences and the possibility of identifying these consequences. Risk assessment measurements consist of 2 parameters, namely severity as seen in Table 1 and the possibility of risk occurrence (probability) as seen in Table 2, and the risk assessment matrix can be seen in Table 3. While determining the risk level can be divided into several categories which can be seen in Table 4.

The risk level value can therefore be calculated using the following equation::

$$\text{Risk Level (R)} = \text{S (Severity)} \times \text{P (Probability)} \quad (1)$$

The risk assessment process is carried out with the aim of identifying and finding hazards that may occur in an organization's activities and ensuring that risks that may arise to workers or people in an organization can be assessed, prioritized and controlled at an acceptable level.

Table 8. Risk Assessment Matrix for Initial Control in the Process of Activities "Welding Using Portable Welding.

Severity Level (S)	Risk Probability (P)				
	A *(Never)*	B (Rarely)	C (Seldom)	D (Often)	E (Always)
5 (Extreme)	5A	5B	5C	5D	5E
4 (Major)	4A	4B	4C	4D	4E
3 (Moderate)	Preparation, Welding & Tidying up equipment: Manual lifting, non-ergonomic body position, welding flame, electricity	Preparation & Tidying Up: Manual handling, sharp corners	3C	3C	3D
2 (Minor)	Portable Welding & Tidying up equipment: welding heat, welding fumes, dust	2B	2C	2D	2E
1 (Not Significant)	1B	1B	1C	1D	1E

Table 9. Risk Assessment in the Process of Activities "Welding Using Portable Welding".

Detail of Activities	Hazard Description	Risk	Current control	Condition (R/NR/E)	Regulation	Initial Risk Value		
						S	P	R
Equipment preparation	Manual handling	Spinal injury	Spinal injury	Routine	Yes	3	B	3B
	Manual lifting	Muscle injury	Muscle injury	Routine	Yes	3	A	3A
	Sharp corners	Graze/	Graze/	Routine	Yes	3	B	3B
	Non-ergonomic body position	Injuries	Injuries	Routine	Yes	3	A	3A
Welding using portable welding	Welding heat	Skin irritation	Using coverall and welding gloves	Routine	Yes	2	A	2A
	Welding fumes	Respiratory disorders	Using welding face shield	Routine	Yes	2	A	2A
	Welding flame	Burns	Using coverall	Routine	Yes	3	A	3A
		Fire	Keep flammable materials away from the welding area, provide dry powder type APAR in the work area	Routine	Yes	4	A	4A
	Non-ergonomic body position	Sprains	Do the work with the appropriate body position	Routine	Yes	3	A	3A
	Electricity	Fire	Keep flammable materials away from the work area, provide APAR	Routine	Yes	3	A	3A
Tidying up portable welding equipment	Manual handling	Spinal cord injury	Perform manual handling correctly	Routine	Yes	3	B	3B
	Manual lifting	Muscle injury	Perform manual lifting correctly	Routine	Yes	3	A	3A
	Dust	Respiratory distress	Use welding face shield	Routine	Yes	2	A	2A
	Sharp corners	Scratches/cuts	Recognize and avoid sharp corners on materials & work equipment, use welding gloves	Routine	Yes	3	B	3B
	Non-ergonomic body position		Perform work with appropriate body position	Routine	Yes	3	A	3A
	Electricity	Sprains	Ensure all welding equipment is disconnected from the electrical current	Routine	Yes	3	A	3A

Table 10. Risk Assessment Matrix for Initial Control in the Process of Activities "Welding Using Portable Welding"

Severity Level (S)	Risk Probability (P)				
	A *(Never)*	B (Rarely)	C (Seldom)	D (Often)	E (Always)
5 (Extreme)	5A	5B	5C	5D	5E
4 (Major)	4A	4B	4C	4D	4E
3 (Moderate)	Preparation, Welding & Tidying up equipment: Manual lifting, non-ergonomic body position, welding flame, electricity	Preparation & Tidying Up: Manual handling, sharp corners	3C	3C	3D
2 (Minor)	Portable Welding & Tidying up equipment: welding heat, welding fumes, dust	2B	2C	2D	2E
1 (Not Significant)	1B	1B	1C	1D	1E

Table 11 Risk Level Analysis Results in Initial Control

No	Job Activity	Initial risk			Level of Risk
		L	M	H	
1.	Cutting Iron Pipes	8	3	0	11
2.	Welding Using Electric Welding	18	2	0	20
3.	Welding Using Portable Welding	16	0	0	16
	Amount of Risk	Amount of Risk	5	0	47
	(%)	89,37%	10,63%	0%	100%

Table 12 Risk Control and Reduction in the Process of "Iron Pipe Cutting" Activities

Detail of Activities	Hazard Description	Risk	Current control	Condition (R/NR/E) S	P	R	Regulation	Detail of Activties S_1	P_1	R_1
Preparation of pipe cutting equipment	Manual Handling	Spinal cord injury	Carrying out proper handling, manually should not weigh more than 20kg/person	3	B	3B				
	Manual lifting	Muscle injury	Performing proper lifting	3	C	3C	Using tools such as forklifts/cranes (if the load weight is ≥20kg)	3	A	3A
	Material welding	Deep laceration	Using welding gloves	3	B	3B				
Pipe cutting using a cutting torch	Pressurized cylinders (oxygen cylinders, acetylene/LPG)	Death, Injury to limbs	Place the tube in a safe place, tie it so it doesn't fall	5	A	5A	Use a good regulator and hose (no leaks), check the hydro test period, use PPE	4	A	4A
	Welding hose (for oxygen, acetylene/LPG)	Respiratory disorders	Using a good regulator & hose (no leaks)	3	B	3B				
	Welding hot steam	Eye irritation	Using a welding face shield/safety goggles	1	B	1B				
	Welding fumes	Respiratory disorders	Using a welding face shield/mask	2	A	2A				
	Welding fire	Burns	Use appropriate PPE for welding work (safety helmet, welding face shield, coverall, welding gloves, safety shoes)	3	A	3A				
Tidying up iron pipe cutting equipment	Manual handling	Spinal cord injury	Carry out proper handling, lifting goods manually should not weigh more than 20kg/person	3	B	3B				
	Manual lifting	Muscle injury	Doing lifting correctly	3	C	3C	Using tools such as forklifts/cranes (if the load weight is ≥20kg)	3	A	3A
	Welding material residue	Deep scratch wound	Deep scratch wound	3	B	3B				

Table 13. Risk Reduction Matrix in Advanced Control in the Process of " Iron Pipe Cutting " Activities

Severity level (S)	Risk Probability (P)				
	A (Never)	B (Rarely)	C (Seldom)	D (Often)	E (Always)
5 (Extreme)	5A	5B	5C	5D	5E
4 (Major)	Pipe cutting: Pressure tube	4B	4C	4D	4E
3 (Moderate)	Pipe cutting: Welding flame Preparation and tidying up of equipment: Manual lifting	Equipment preparation: Manual handling, welding material Pipe cutting: Welding hose Equipment tidying: Manual handling, remaining welding material	3C	3C	3D
2 (Minor)	Pipe cutting: Welding fumes	2B	2C	2D	2E
1 (Not Significant)	1A	Pipe cutting: Welding hot steam	1C	1D	1E

RESULTS AND DISCUSSION

Risk assessment is the identification of risk hazards through risk hazard analysis and evaluation intended to determine the magnitude of the risk by considering the possibility of probability and the severity. The parameters used to conduct risk assessment are probability and severity. Probability is the level of possibility of a work accident risk, and severity is the level of severity caused by the risk. Risk assessment describes how big the impact of the potential hazards and risks that arise will then be seen with the help of a risk analysis matrix table.

Occupational Accident Risk Assessment in Ship Pipe Welding Work LSM Provider

Risk assessment in the HIRADC table with pipe welding work divided into 3 activities, namely 1) Cutting iron pipes (See Table 5 and Tabel 6); 2) Welding using electric welding (See Table 7 and Tabel 8); and 3) Welding using portable welding (See Table 9 and Table 10).

Risk assessment is conducted with the aim of determining the level of risk that has been carried out after conducting hazard identification. The results of the risk level analysis in initial control can be seen in Table 11.

From the results of the risk assessment in the initial control, the percentage form above shows that Low Risk level work gets a percentage of 89.37%, Medium Risk level work gets a percentage of 10.63%, and High-Risk level work gets a percentage of 0%.

Occupational Accident Risk Control in Ship Pipe Welding Work LSM Provider

Although a number of risks are still identified, the control measures taken have made a positive contribution to reducing the potential for accidents and injuries [13]. After a risk assessment is carried out with initial controls determined by the control hierarchy method, the color results of the risk assessment will appear. If the color is "RED" then it is an unacceptable risk level and the risk must be reduced to "YELLOW or GREEN". If the color is "YELLOW" then it is a risk level that is still tolerable but further control must still be carried out to reduce the risk to "GREEN". If the risk assessment is already "GREEN" then it is an acceptable risk level but is still controlled with periodic monitoring. Control and Risk Reduction in the "Iron Pipe Cutting" Activity Process can be seen in Table 12 and Table 13. Control and Risk Reduction in the " Welding using electric welding " Activity Process can be seen in Table 14 and 15.

Table 14 Control and Risk Reduction in the " Welding using electric welding " Activit.

Detail of Activties	Hazard Description	Risk	Current control	Condition (R/NR/E) S	P	R	Regulation	Detail of Activties S_1	P_1	R_1
Preparation of electric welding equipment	Manual handling	Spinal injury	Carry out proper handling, lifting goods manually should not weigh more than 20kg/person	3	B	3B				
	Manual lifting of materials	Muscle injury	Doing lifting correctly	3	C	3C	Using tools such as forklifts/cranes (if the load weight is ≥ 20kg)	3	A	3A
	Sharp corners	Scratches/wounds	Recognize and avoid sharp corners on materials & work equipment, use welding gloves	3	B	3B				
	Dust	Respiratory disorders	Using a welding face shield/mask	2	A	2A				
	Non-ergonomic body position	Sprains	Doing work with the appropriate body position	3	A	3A				
		Electric shock from generator	Using cables of the appropriate size, filling out the work permit form checklist before doing hot work (No. Doc. F/LS-QHSE/28)	4	A	4A				
Welding using electric welding	Welding heat	Skin irritation	Using coveralls and welding gloves	2	A	2A				
	UV radiation	Visual impairment	Using a welding face shield	1	A	1A				
	Unergonomic body position	Sprain	Do the work with the appropriate body position	3	A	3A				
	Electricity	Electric shock from generator	Using cables of the appropriate size, filling out the work permit form checklist before carrying out hot work (No. Doc. F/LS-QHSE/28)	4	A	4A				
		Fire	Keep flammable materials away from the welding area, provide dry powder type APAR in the work area.	4	A	4A				
	Welding fumes	Respiratory disorders	Using a welding face shield/mask	2	A	2A				
	Welding fire	Burns	Use complete PPE according to welding work standards	3	A	3A				
		Fire	Keep flammable materials away from the welding area, provide dry powder type APAR in the work area.	4	A	4A				
Tidying up welding equipment	Manual handling for materials	Spinal cord injury	Carry out manual handling properly, goods ≥ 20kg are not allowed manually	3	B	3B				
	Manual lifting	Muscle injury	Carry out manual lifting correctly	3	C	3C	Using tools such as forklifts/cranes (if the load weight is ≥ 20kg)	3	A	3A
	Welding material residue	Deep scratch wound	Using welding gloves	3	B	3B				
	Non-ergonomic body position	Sprain	Doing work with the appropriate body position	3	A	3A				
	Electricity	High voltage electric shock	Doing work with the appropriate body position	4	A	4A				

Table 15 Risk Reduction Matrix in Advanced Control in the Process of " Welding using electric welding " Activities

Severity (S)	Risk Probability (P)				
	A (Never)	B (Rarely)	C (Seldom)	D (Often)	E (Always)
5 (Extreme)	5A	5B	5C	5D	5E
4 (Major)	Equipment preparation and Welding: Electricity	4B	4C	4D	4E
3 (Moderate)	Preparation, Welding, and Tidying up of equipment: Unergonomic body position, welding flame, manual lifting	Preparation and Tidying up of equipment: Manual handling, sharp corners, leftover welding material	3C	3C	3D
2 (Minor)	Equipment preparation: Dust	2B	2C	2D	2E
1 (Not Significant)	Welding: Welding heat, welding fumes	1B	1C	1D	1E

Advanced risk control is carried out to reduce the hazard risk value, so that all become “GREEN” or “Low Risk”. The results of the risk level analysis in advanced control can be seen in the Table 16.

Table 16 Risk Reduction Matrix in Advanced Control in the Process of "Iron Pipe Cutting" Activities

No	Job Activity	Initial risk			Risk Level
		L	M	H	
1.	Iron Pipe Cutting	11	0	0	11
2.	Welding Using Electric Welding	20	0	0	20
3.	Welding Using Portable Welding	16	0	0	16
	Amount of Risk	47	0	0	47
	%	100%	0%	0%	100%

From the results of the advanced control and risk reduction that have been carried out, it shows that all pipe welding jobs at the “Low Risk” level have received a percentage of 100%. The risk assessment graph for initial control and after advanced control and risk reduction can be seen in Figure 1.

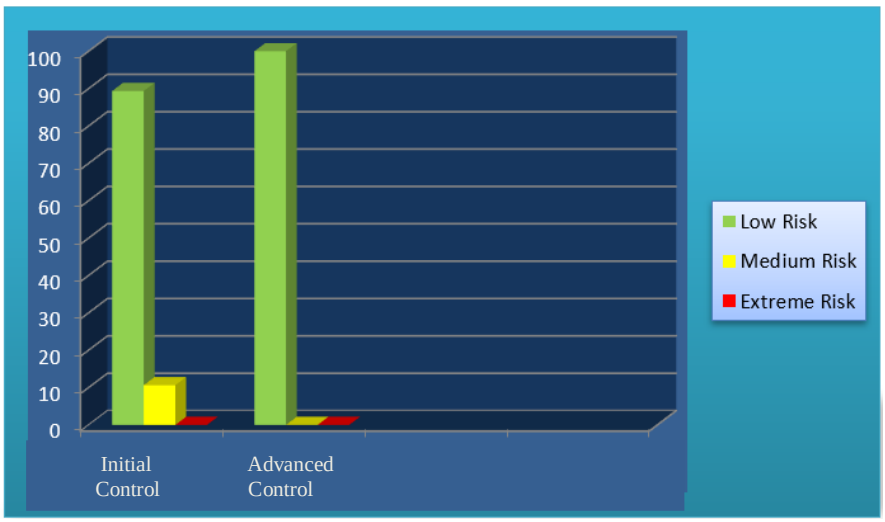

Figure 1. Comparison Chart of Risk Assessment in Initial Control and Continued Control.

CONCLUSION

Based on the research that has been conducted on the welding work of LSM Provider ship pipes owned by PT LSM which was carried out when the ship entered the workshop (Muara Kembang), it can be concluded that 1) Based on hazard identification using the HIRADC method (Hazard Identification, Risk Assessment, and Determining Control), the hazards identified in the welding work of LSM Provider ship pipes showed 43 potential hazards with a total of 47 risks. Low Risk level risks amounted to 42 risks (89.37%), Medium Risk level risks amounted to 5 risks (10.63%), and High-Risk risks amounted to 0 risks (0%). Included in the Low Risk level risks are manual handling, welding material, welding hose, hot welding steam, welding fire, welding material residue, dust, non-ergonomic body position, electricity, UV radiation, welding smoke, and sharp corners. While those included in the Medium Risk level risks are manual lifting, and pressurized cylinders. 2) After risk control was carried out, there was a decrease in risk, from the initial Medium Risk level of 5 risks (10.63%) it has decreased to Low Risk. It can be stated that all risk hazards in pipe welding work are at the Low Risk level with a total of 47 risks (100%) already in the color "GREEN" which means it is a risk level that can be accepted and controlled with periodic monitoring.

REFERENCES

[1] G. A. A. Bangun and W. Hariyono, "Analisis Penerapan Keselamatan dan Kesehatan Kerja (K3) pada Kapal Penumpang di PT PELNI Semarang," *Semin. dan Konf. Nas. IDEC*, vol. 3, no. 2579–6429, pp. 1–6, 2019.

[2] C. Jurnal, S. Pramono, and D. Affiyanto, "Analisa Perhitungan Diameter Pipa Kapal Berdaya Mesin 4000 BHP Info Articles Abstrak," vol. 1, no. 2, pp. 56–63, 2024, [Online]. Available: http://e-journal.ivet.ac.id/index.php/maristec

[3] A. Ouadah, "Pipeline Defects Risk Assessment Using Machine Learning and Analytical Hierarchy Process," *Proc. 2018 Int. Conf. Appl. Smart Syst. ICASS 2018*, no. November, pp. 1–6, 2018, doi: 10.1109/ICASS.2018.8651970.

[4] A. Banaszek, Z. Łosiewicz, and W. Jurczak, "Corrosion Influence on Safety of Hydraulic Pipelines Installed on Decks of Contemporary Product and Chemical Tankers," *Polish Marit. Res.*, vol. 25, no. 2, pp. 71–77, 2018, doi: 10.2478/pomr-2018-0056.

[5] H. Huang, Z. Yuan, H. Qian, Y. Ye, J. Leng, and Y. Wei, "Design and analysis of a novel ship pipeline welding auxiliary device," *Ocean Eng.*, vol. 123, pp. 55–64, 2016, doi: 10.1016/j.oceaneng.2016.06.050.

[6] E. Turan, "Welding Technologies in Shipbuilding Industry," *Tojsat*, vol. 1, no. 4, pp. 24–30, 2011.

[7] V. R. Lokhande, "Health profile of workers in a ship building and repair industry," *Indian J. Occup. Environ. Med.*, vol. 18, no. 2, pp. 89–94, 2014, doi: 10.4103/0019-5278.146898.

[8] S. Y. Yang, J. M. Lin, W. Y. Lin, and C. W. Chang, "Cancer risk assessment for occupational exposure to chromium and nickel in welding fumes from pipeline construction, pressure container manufacturing, and shipyard building in Taiwan," *J. Occup. Health*, vol. 60, no. 6, pp. 515–524, 2018, doi: 10.1539/joh.2018-0075-FS.

[9] J. D. Fairussihan and D. Setiono, "Analisis Risiko Keselamatan Dan Kesehatan Kerka (K3) Pada Proses Perbaikan Kapal Di Pt. Dock Dan Perkapalan Surabaya Menggunakan Metode Hirarc (Hazard Identification, Risk Assessment, And Risk Control)," *Zo. Laut J. Inov. Sains Dan Teknol. Kelaut.*, pp. 23–29, 2023, doi: 10.62012/zl.v4i1.18977.

[10] W. Tambunan, "Analisis Risiko Keselamatan dan Kesehatan Kerja Menggunakan Metode Hirarc pada Proses Perbaikan Kapal Tugboat (Studi Kasus PT Marga Surya Shipindo, Samarinda)," *J. Ind. Manuf. Eng.*, vol. 3, no. 1, p. 33, 2019, doi: 10.31289/jime.v3i1.2525.

[11] R. Zaidi *et al.*, "Risk assessment of oil drilling rig welded pipe based on structural integrity and life estimation," *Eng. Fail. Anal.*, vol. 112, no. November 2019, p. 104508, 2020, doi: 10.1016/j.engfailanal.2020.104508.

[12] T. S. P. Petroleo, C. Alberto, P. Petroleo, A. S. Xavier, and P. Petroleo, "IPC2000-139," 2001.

[13] Muhammad Luqman Dzaky and Naniek Ratni JAR, "Analisa Risiko Keselamatan Dan Kesehatan Kerja (K3) Pada Kegiatan Docking Di PT. Pelindo Marine Service," *J. Univers. Tech.*, vol. 3, no. 1, pp. 13–27, 2024, doi: 10.58192/unitech.v3i1.1858.

[14] M. J. Anbari, M. Tabesh, and A. Roozbahani, "Risk assessment model to prioritize sewer pipes inspection in wastewater collection networks," *J. Environ. Manage.*, vol. 190, pp. 91–101, 2017, doi: 10.1016/j.jenvman.2016.12.052.

[15] N. Faizah, E. Purnamawati, and T. Tranggono, "Analisis Risiko K3 Pada Kegiatan Reparasi Kapal dengan Menggunakan Metode Hazard Identification, Risk Assessment and Determining Control (HIRADC) dan Metode Job Safety Analysis (JSA) pada PT. NF," *Juminten*, vol. 2, no. 5, pp. 74–85, 2021, doi: 10.33005/juminten.v2i5.316.