Conference Paper

Risk Assessment of Occupational Health and Safety of Offshore Pipe Coatings

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Abstract

Risk assessment is one of the most important aspects of occupational health and safety. In particular, risk assessment aims to minimize and prevent accidents. It is important to perform risk assessments prior to starting projects and to regularly review risk assessments. This is especially true in the oil and gas industry because of the high associated risks. The present research study aims to identify the level of safety and risks in the process of coating offshore pipelines at one company. The semi-quantitative AS/NZS 4360 2004 method of risk analysis based on the Fine & Kinney criteria was used. This study is descriptive and has a cross-sectional design. The identified hazards were physical, chemical, ergonomic and fire hazards. The highest risk levels were associated with working at heights, pipe surface cleaning using the MBX pneumatic metal blaster and Kevlar installation. Safety controls are in place; however, working at heights still presents a substantial risk. The most common factors associated with falls from heights are unadequate safety standards and facilities.

Keywords: risk assessment, occupational health and safety risk, coating, corrosion control

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1. Introduction

Occupational Safety and Health (OSH) is a field concerned with guaranteeing and protecting the safety and health of the workforce through preventing occupational injuries and illnesses. Every job has potential risks and accidents. Failures in interactions or processes involving humans, machines, materials, and the environment can potentially cause accidents. The impact of accidents can include injury or death of workers, damage to production facilities, cessation of production processes, claims or compensation, social impacts, and environmental pollution [1].

The oil and gas industry is one industry with a high level of risk. Safety hazards, health hazards, and hazardous working conditions in the oil and gas industry are related to transportation, being struck by an object, work experience in the industry, falling from heights, exposure to chemical materials, limited space, slips, trips, explosions, and fires [2].

Data on accidents related to upstream oil and gas activities in Indonesia are recorded by Directorate General of Oil and Gas, Ministry of Energy and Mineral Resources of Indonesia. In 2011, 168 accidents occurred that resulted in 11 deaths. In 2012, 99 accidents occurred that resulted in 8 deaths. In 2013, 183 accidents occurred that resulted in 4 deaths. In 2014, 202 accidents occurred that resulted in 6 deaths. In 2015, total of accidents increased to 273, although the number of deaths decreased to 2 people [3].

In the oil and gas industry, pipelines are the main components used to distribute oil and gas. Pipelines may potentially undergo corrosion, a natural process that is not completely preventable. Furthermore, the potential for corrosion is present at every stage of production, extraction, refinement, and storage where metal materials are used [4]. The impacts of corrosion are decreased metal quality, strength, and thickness and can also lead to broken pipes or oil leaks that may pollute the environment, release flammable gas, stop production processes because of the need to replace pipelines, and cause financial losses [5, 6].

The application of pipe coating is one method used to prevent and control rust on pipes [7, 8]. Basically, coatings contain chemical compounds such as synthetic resins or inorganic silicate polymers. When applied to a prepared surface, the chemicals in a coating will form a seal on a pipe that resists the negative effects of harsh environments and that prevents electrochemical corrosion processes [9].

During the coating of pipes, there is a risk of accidents and occupational illness. Accident prevention efforts can be carried out based on prior risk assessments. In this context, risk assessment is a process to identify risks, to measure hazards or risks, and to establish the level or probability of risks in order to develop a strategy to control the associated risks. In other words, risk assessment can serve as a basis for precautionary measures and for controlling potential hazards during the pipe coating process. Therefore, a risk assessment of the offshore pipe coating process was carried out in the present study to identify potential hazards and means of controlling the identified risks.

2. Methods

The present study was formulated as descriptive study with a cross-sectional design in order to determine the level of risk of the pipe coating process in an offshore area. The employed risk analysis (AS/NZS 4360: 2004) was semi-quantitative and was carried out in the offshore area of PT X in August 2017. The objectives of the assessment were to identify hazards, to assess safety and health risks, and to determine the risk level of the offshore pipe coating process.

Primary data were obtained from observations and interviews. Observations were conducted to observe the work processes and stages, the environmental conditions, the utilized equipment and materials, and the safety measures set in place by the company. Unstructured interviews were carried out with eight workers. The interviews were conducted to obtain more detailed information on the work processes and stages related to pipeline coating, potential hazards posed by the work, and the habits undertaken by workers.

Secondary data were obtained from the company to complement the results of the observations and interviews, including Standard Operating Procedure and documentation on utilized tools, materials, and Occupational Safety Health activities as well as other supporting data.

The risk identification was performed via a job safety analysis (JSA). In this analysis, potential hazards and existing risks are identified at each stage of a work process. Then, the risk scores are calculated using a fine chart to determine the corresponding values of risk consequence, exposure, and probability (Tables 1–3) [10].

After obtaining these values, a final risk score for each stage of the work is obtained by calculating the following formula:

$$\text{Risk score} = \text{consequences} \times \text{exposure} \times \text{probability}$$

The resulting risk scores from each stage of the work can then be assigned a risk level according to Kinney's criteria (Table 4) [11].

This step is used to determine the level of safety and risks whether the identified risks are acceptable or not.

3. Results

During the present study, potential hazards during the pipe coating process of an offshore area were identified via observations and interviews, and a job safety analysis

Table 1: Rating on consequences.

Factor	Level	Description	Rating
Consequences Consequences arising from an event/incident	Catastrophe	High number of deaths, fatal/severe damage to various facilities over $1 million	100
	Disaster	Several deaths, loss of $500,000–1,000,000	50
	Very Serious	Death, loss of $100,000–500,000	25
	Serious	Serious, permanent disability or pain, loss of $1000–100,000	15
	Important	Medical treatment is required, damage, losses up to $1000	5
	Noticeable	Injuries or minor pain, light loss > $100	1

Table 2: Rating on exposure.

Factor	Description		Rating
Exposure Exposure frequency against hazards	Continously	Often occur in a day	10
	Frequently	About once a day	6
	Occasionally	1 time a week to 1 time a month	3
	Unusual	1 time in a month to once a year	2
	Rarely	Known when it happened	1
	Very Rare	Unknown when it happened	0.5

was carried out to assess the existing hazards of the workplace. The obtained data were analyzed to assign the values to the identified risks after safety controls were contemplated. The identified hazards during pipe coating activities in the offshore area included physical, chemical, ergonomic and fire hazards. The types of risks related with pipe coating activities in the offshore area were falling from heights, slipping, tripping, fires, noise, scratched hands, dust-exposed eyes, dust inhalation, tiredness, awkward positions, respiratory irritation, skin irritation, and eye irritation (Table 5).

Table 3: Rating on probability.

Factor	Level	Description	Rating
Probability Possibilities accompanying an outcome	Almost certain	The most frequent occurrences	10
	Likely	50% chance of accident	6
	Unusual but possible	Unusual but possible	3
	Remotely possible	Unlikely to happen	1
	Conceivable	There has been no accidents in the years of exposure but it may occur	0.5
	Practically Imposible	Very unlikely to happen	0.1

Table 4: Risk level.

Risk Level	Category	Action
> 400	*Very High*	Consider discontinuing operation
200–400	*High Risk*	Immediate correction required
70–200	*Subtancial Risk*	Correction needed
20–70	*Possible Risk*	Attention indicated
< 20	*Acceptable*	Perhaps acceptable

Table 5: Analysis of occupational safety risk on pipe coating in the offshore area.

Stage of Work	Type of Risk	Risk Level Basic Risk	Existing Control	Risk Level Existing Risk
Working at height	Falling	Very High	· Scaffolding is available with walkway width of 80 cm and midrail height of 50 cm	Subtantial
			· Permit to work	
			· Internal training to work at height	
			· Scaffolding inspection	
Determining location, pipes marking, calculate hygrometric and supporting temperature	Slipping	Subtantial	· Housekeeping	Possible
	Tripping		· Wearing personal protective equipment (safety helmet, shoes)	

Stage of Work	Type of Risk	Risk Level Basic Risk	Existing Control	Risk Level Existing Risk
			Wearing chinstrap (not all workers wear chinstrap)	
Cleaning the pipe surface using MBX Pneumatic	Fire	Very High	· Standard Opetaing Procedure	Acceptable
			· Certified Applicator	
			· Measuring H2S gas and ensuring no H2S leakage	
			· Using certified Pneumatic MBX tool	
			· Splashing the pipe area cleaned using Pneumatic MBX	
			· Providing fire extinguishers	
	Noise	Possible	· All workers wear earplugs	Acceptable
	Hand scratched	Subtantial	· Workers wear gloves (not all workers wear gloves & not in accordance with the safety standard)	Possible
	Dust exposed-eyes	Possible	· All workers wear safety glass in accordance with safety standard	Acceptable
	Inhaled dust	Subtantial	· Workers wear masks (not all workers wear masks in accordance with the standard)	Possible
	Tiredness	High	· Set a break time	Acceptable
			· Provision of adequate drinking water	
			· Use of MBX tools is performed alternately by a minimum of 2 workers	
	Ergonomics	Subtantial	· Set a break time	Possible
Cleaning the pipe surface using aceton	Respiratory Irritation	Subtantial	· Material Ssafety Data Sheet is available	Possible
			· Workers wear masks (not all workers wear masks in accordance with the standard)	
	Skin Irritation	Subtantial	· Material Ssafety Data Sheet is available	Possible
			· Workers wear rubber gloves, safety shoes and coverall in accordance with the standard	
	Eye Irritation	Possible	· All workers wear safety glass in accordance with the standard	Acceptable

Stage of Work	Type of Risk	Risk Level Basic Risk	Existing Control	Risk Level Existing Risk
Preparing filler and applying filler to pipes	Respiratory Irritation	Subtantial	· Material Ssafety Data Sheet is available	Possible
			· Workers wear masks	
	Skin Irritation	Subtantial	· Material Ssafety Data Sheet is available	Possible
			· Workers wear rubber gloves, safety shoes, safety glass and disposable coverall	
	Eye Irritation	Possible	· All workers wear safety glass in accordance with the standard	Acceptable
Preparing resin and applying resin on pipes	Respiratory Irritation	Subtantial	· Material Ssafety Data Sheet is available	Possible
			· Workers wear masks (not all workers wear masks in accordance with the standard)	
	Skin Irritation	Subtancial	· Material Ssafety Data Sheet is available	Possible
			· Workers wear rubber gloves, safety shoes, safety glass and disposable coverall	
	Eye Irritation	Possible	· All workers wear safety glass in accordance with the standard	Acceptable
Kevlar installation on pipe and the application of resin on kevlar	Ergonomics	High	· Set a break time	Possible
			· Work is performed by 8 workers	
	Skin Irritation	Subtantial	· Material Ssafety Data Sheet is available	Possible
			· Workers wear rubber gloves, safety shoes, safety glass and disposable coverall	
	Respiratory Irritation	Subtantial	· Material Ssafety Data Sheet is available	Possible
			· Workers wear masks (not all workers wear masks)	
	Tiredness	Very High	· Set a break time	Acceptable
			· Provision of adequate drinking water	
			· Work is performed by 8 workers	

Stage of Work	Type of Risk	Risk Level Basic Risk	Existing Control	Risk Level Existing Risk
	Eye irritation	Possible	· All workers wear safety glass in accordance with the standard	Acceptable
	Hand scratched	Possible	· Workers wear gloves	Acceptable
			· Kevlar cutting is performed by min. 2 workers	
Pipe hardness checks	Sliping	Subtantial	· Housekeeping	Possible
	Tripping		· Wear personal protective equipment (safety helmet, shoes)	
			· Wear chinstrap (not all workers wear chinstrap)	

Of the basic risks identified during the risk analysis, 3 of the identified risks (11.54%) are very high, while 2 risks (7.69%) were categorized as high, 14 risks (53.85%) as substantial, and 7 risks (26.92%) as possible. None of the identified risks (0%) were considered acceptable (Scheme 1).

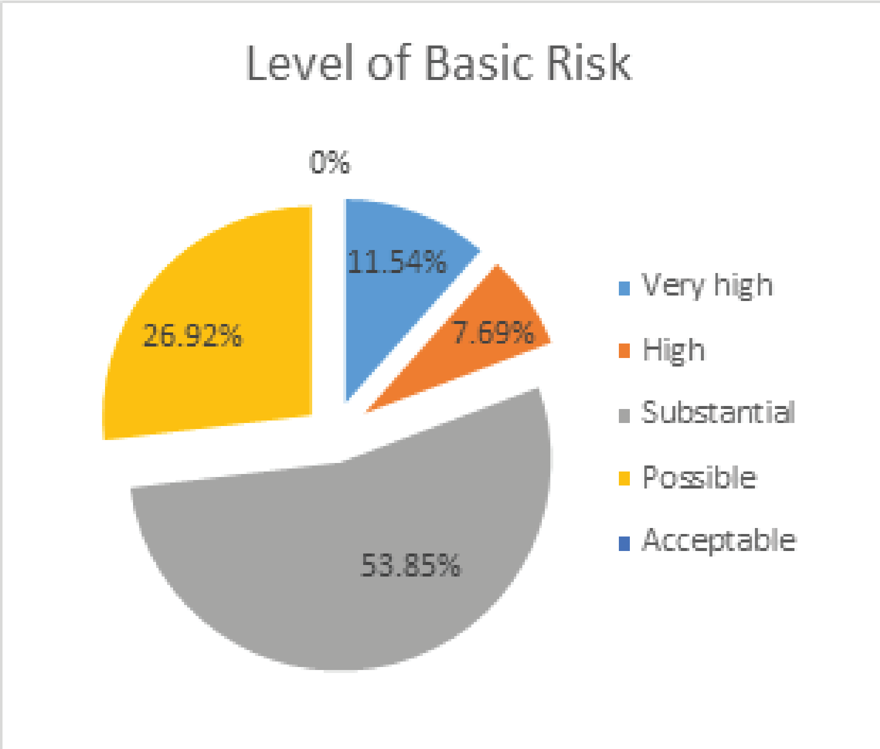

Figure 1: Level of basic risk.

However, with respect to the existing risks, no risks (0%) are very high or high, while 1 risk (3.85%) was categorized as substantial and 15 risks (57.69%) as possible. Finally, 10 risks (38.46%) were considered to be acceptable (Scheme 2).

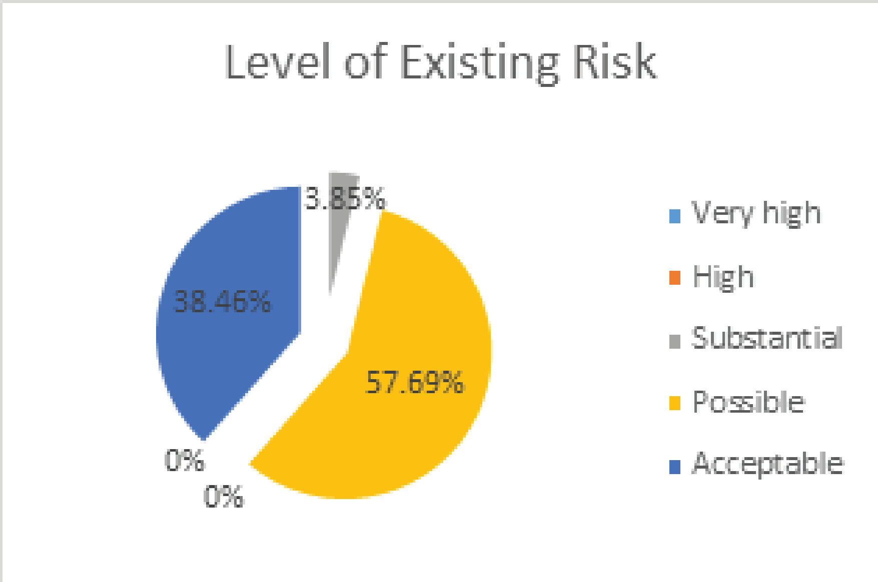

Figure 2: Level of existing risks.

4. Discussion

In this study, the potential risks of offshore pipe coatings are identified through the following work stages:

1. Working at heights is one significant risk undertaken by workforces at workplaces with height differences between working surfaces (e.g., between the soil, water, or platforms). In such environments, potential falls can result in injury or death or can cause damage to objects [12]. In offshore oil environments, pipe coating work is often performed at a height of 5 meters from the platform, so this task is categorized as working at a height. In the present analysis, working at a height was associated with a substantial level of existing risk. Those who perform this job are at risk of falling and potentially experiencing work accidents. Because of this observation, a number of safety controls have been put into place, such as the use of scaffolding with a walkway width of 80 cm and a mid-rail height of 50 cm. Employees also undergo internal training about working at heights and must receive a permit to perform this work. Previously, one of the causes of falling from staging scaffolding was identified to be the lack of safety interventions or compliance with standard scaffolding [13]. The lack of safety facilities is another factor that can cause workers to fall from a height [14]. To prevent falling from heights, guardrail installations of a height of 90 cm to 120 cm are required by OHSA [15].

2. Also, during the coating of pipes, the location of pipes must first be determined, and pipes must also be marked. Furthermore, the hygrometric parameters and supporting temperatures must be calculated. The hazards identified during this phase are slipping and tripping. A number of safety controls have been implemented, namely housekeeping and personal protective equipment provision, but the existing risks are still categorized as possible. This may be realted to the lack of awareness of workers in the use of chinstraps, which would change the associated consequence value in the assessment of these risks. The use of chinstraps can effectively prevent a helmet from being removed and minimize the potential impacts of an accident [16].

3. Cleaning the pipe surface using the MBX pneumatic metal blaster also presents some risk. Pipe cleaning is performed to remove rust and paint from pipes. The identified potential risks are fire, noise, scratched hands, dust-exposed eyes, dust inhalation, tiredness, and muscle cramps. The fire hazard is related to sparks that arise from friction between the pipes, the MBX pneumatic, and H_2S gas [17]. Some safety controls have been used to minimize these latter hazards, such as detecting H_2S before work, using a ignition-free MBX pneumatic device, splashing water on pipelines to reduce spark formation, and having access to a fire extinguisher in case of fire. In the present study, as the potential for fire is very low, the existing risk level of fire is acceptable. However, the existing risk of scratching hands and inhaling dust is possible. Workers did not wear gloves or masks that complied with the established standards. In Indonesia, the standard for protective gloves in the case of mechanical risks is outlined in EN 388, while the standard dust mask is outlined in EN 149 and N95 [18, 19]. Also, during the pipe cleaning process, the position of workers is not ergonomic, as this task may required bending, squatting, and upward head motions. Musculoskeletal disorders may result in workers who do not engage in ergonomic work positions [20, 21]. Safety controls include the establishment of break times. However, the existing risk of musculoskeletal disorders is still possible. Based on study by Choi et al and Gasibat et al, stretching programs is one of administrative control to reduce these associated risks. The objectives of stretching programs might be to prevent injury, to increase flexibility and body movement, and to reduce discomfort, pain, and muscle endurance [20, 21]. In addition, stretching programs can increase awareness and worker communication and can promote team building and safety planning [20].

4. Cleaning the pipe surface using acetone is another cleaning process that is associated with some risk. This pipe cleaning process aims to remove dirt such as dust and oil. During this process, chemical hazards may result from the use of acetone to clean pipes. Specifically, the use of acetone may cause eye, skin, and respiratory irritation [22, 23]. Safety controls include the provision of material safety data sheet and the use of safety glass (ANSI Z97.1), gloves, and masks (standard EN 374). The utilized mask in these cases is both a dust and a cloth mask, so the acetone vapor is filtered and cannot enter into a worker's respiratory system [24]. In the present study, the existing risk level of skin irritation and respiratory irritation during this process was categorized as possible.

5. Preparing filler and applying filler to pipes was another identified risk. The application of filler on pipes aims to patch leaks or holes in defective pipes. The filler material is composed of silicon carbide, titanium dioxide, and diethylenetriamine. However, these materials can invade the respiratory system [23]. In addition, diethylenetriamine may also cause eye irritation [23]. Workers in contact with these chemicals may be at risk of skin irritation [25]. During the present observations, we identified safety controls to minimize the risk of respiratory, skin, and eye irritations include the provision of material safety data sheet, safety glass (ANSI Z97.1), gloves (EN 374 standard), chemically resistant coveralls (EN ISO 13982-1: 2004 + A1: 2010 and EN 13034: 2005 + A1: 2009), and dust masks. The respiratory tract may also be irritated because of the generated particulate matter and steam, so the use of an appropriate mask equipped with a dust filter and organic vapor according to NIOSH standards is required. During this process, the existing risk level of skin irritation and respiratory irritation was categorized as possible.

6. Preparing resin and applying resin on pipes was an additional identified risk. During this process, several chemical hazards can be identified. The resin material contains epichlorohydrin and isophorone diamine. Epichlorohydrin may cause respiratory irritation and may have an effect on male reproduction, whereas isophorone diamine may cause respiratory irritation, skin irritation, and eye irritation 27]. In this present study, safety controls are in place in relation to the preparation and application of filler on pipes.

7. Kevlar installations on pipes and the application of resin on kevlar are additional risks. The installation of kevlar on pipes aims to strengthen pipe structure. In this process, ergonomic hazards are identified, as this work may involve some

awkward positions. One safety control is setting a break time. However, musculoskeletal disorders are still a risk, so the existing risk level is categorized as possible. During the present observation, the risk of tiredness has also been identified in workers while kevlar installation. Workers must continuously perform Kevlar installations until all pipe surfaces are coated. The arrangement of breaks may help to avoid fatigue and distress in workers over the work day [28, 29]. In the present study, the use of an adequate amount of workers and the arrangement and rotation of break times lowered the risk level to acceptable.

8. Pipe hardness checks are performed after kevlar and resin applications are dry but are also associated with some risk. While checking the hardness of pipes, slipping and tripping are potential risks. Safety controls for these risk have not been implemented, so the resulting consequences did not decrease in the present analaysis, wherein these risks were categorized as possible.

5. Conclusion

In the present study, the risks associated with pipeline coating work processes in offshore areas were assessed. In general, the existing risks are either possible or acceptable according to the utilized risk categorization (Schemes 1–3).

The highest risks were associated with working at heights, pipe surface cleaning using the MBX Pneumatic metal blaster, and the installation of Kevlar on pipes. Safety controls have been implemented, although the risks of working at heights have not been adequately addressed. Scaffolding safety standards are not met under the present scenario, as the utilized scaffolds are not equipped with guardrails. So, the potential to fall from heights remains, and further safety controls are needed.

References

[1] Ramli, S. (2010). Sistem Manajemen Keselamatan & Kesehatan Kerja OHSAS 18001. Jakarta: Dian Rakyat.

[2] Witter, R. Z., Tenney, L., Clark, S., et al. (2014). Occupational exposures in the oil and gas extraction industry: State of the science and research recommendations. American Journal of Industrial Medicine., vol. 57, no. 7, pp. 847–856.

[3] Kusuryani, Y. (2016). Statistik Minyak dan Gas Bumi 2015.

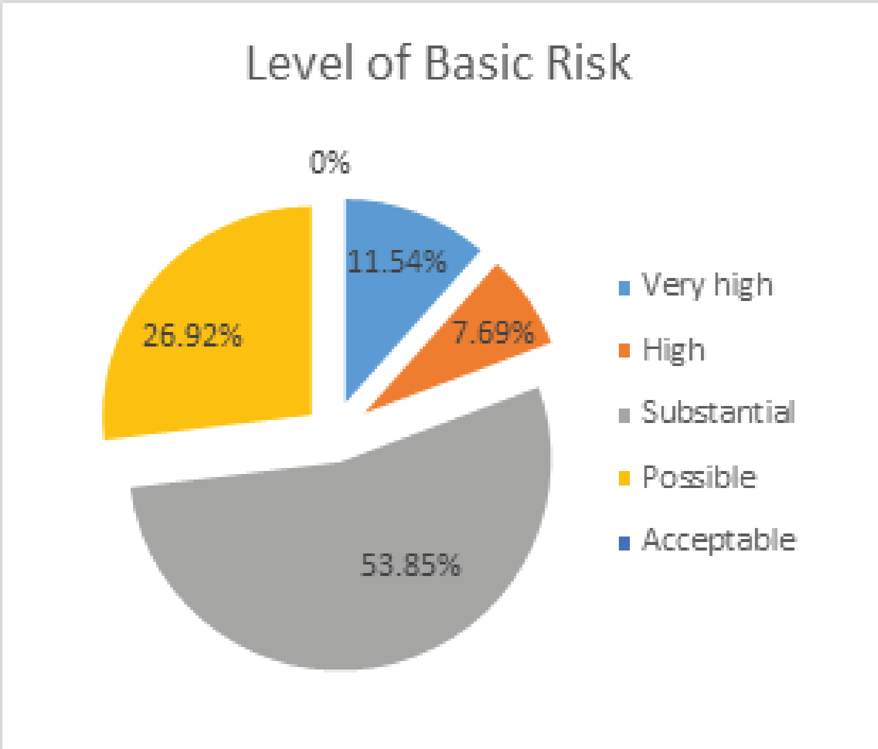

Figure 3: Level of basic risk.

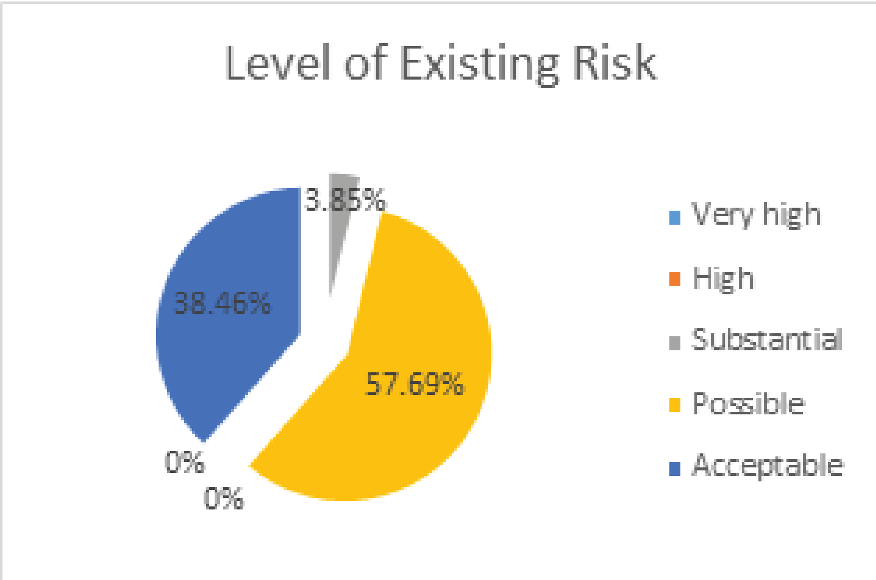

Figure 4: Level of existing risks.

[4] Abd El-Lateef, H. M., Abbasov, V. M., Aliyeva, L. I., et al. (2012). Corrosion protection of steel pipelines against CO2 corrosion—A review. Chemistry: A European Journal, vol. 2, no. 2, pp. 52–63.

[5] Shan, X., Liu, K., and Sun, P.-L.. (2017). Risk analysis on leakage failure of natural gas pipelines by fuzzy bayesian network with a bow-tie model. Science Program,

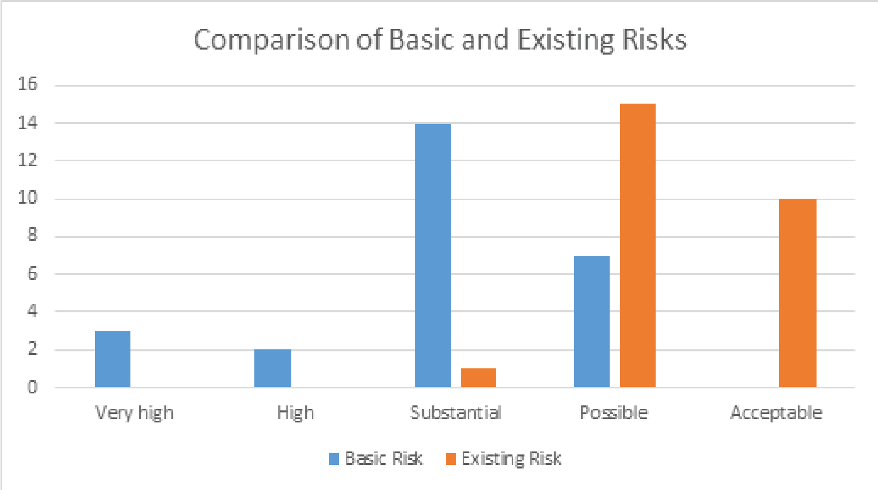

Figure 5: Comparison of basic and existing risks..

vol. 2017, no. 2.

[6] Popoola, L., Grema, A., Latinwo, G., et al. (2013). Corrosion problems during oil and gas production and its mitigation. International Journal of Industrial Chemistry, vol. 4, no. 1, pp. 35.

[7] Enani, J. (2016). Corrosion Control In Oil And Gas Pipelines. International Journal of Scientific & Engineering, vol. 7, (April), pp. 1161–1164.

[8] Groysman, A. (2017). Corrosion problems and solutions in oil, gas, refining and petrochemical industry. Koroze a Ochr. Mater., vol. 61, no. 3, pp. 100–117.

[9] Singh, R. (2014). Corrosion Control for Offshore Structures.

[10] Fine, W. (1971). Mathematical evaluations for controlling hazards. Journal of Safety Research, vol. 3, no. 4, pp. 157–166.

[11] Kinney, G. F. (1976). Practical risk analysis for safety management. Practical Risk Analysis for. Safety Management (June).

[12] Ketenagakerjaan, K. (2016). Peraturan Menteri Tenaga Kerja RI Nomor 9 Tahun 2016 tentang Keselamatan dan Kesehatan Kerja dalam Pekerjaan pada Ketinggian, 37.

[13] Vitharana, V. H. P., De Silva, G. H. M. J. S., and Silva, S. De. (2015). Health hazards, risk and safety practices in construction sites – A review study. Engineer: Journal of the Institution of Engineers, Sri Lanka, vol. 48, no. 3, p. 35.

[14] Nadhim, E., Hon, C., Xia, B., et al. (2016). Falls from height in the construction industry: A critical review of the scientific literature. IInternational Journal of Environmental Research and Public Health, vol. 13, no. 7, p. 638.

[15] United States Department Of Labor. (2002). A Guide to Scaffold Use in the Construction Industry.

[16] Fung, I. W. H., Lee, Y. Y., Tam, V. W. Y., et al. (2014). A feasibility study of introducing chin straps of safety helmets as a statutory requirement in Hong Kong construction industry. Safety Science, vol. 65, pp. 70–78.

[17] Ballantyne, D. (2008). The ShakeOut Scenario Supplemental Study: Oil and Gas Pipelines. Tacoma, WA: SPA Risk LLC.

[18] European Commission. (2017). Personal Protective Equipment. Retrieved from https://ec.europa.eu/growth/smes/access-to-markets/standardisation_en

[19] National Institute for Occupational Safety and Health. (2017). NIOSH-Approved N95 Particulate Filtering Facepiece Respirators. Retrieved from https://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/n95list1.html

[20] Choi, S. D., Rajendran, S., and Ahn, K. (2017). Stretch & flex programs: Effects on the reduction of musculoskeletal disorders & injuries. Professional Safety, vol. 62, no. 5, p. 38.

[21] Gasibat, Q., Bin Simbak, N., and Abd Aziz, A.. (2017). Stretching exercises to prevent work-related musculoskeletal disorders – A review article. American Journal of Sports Science and Medicine, vol. 5, no. 2, pp. 27–37.

[22] U.S. National Library of Medicine. (2015). "Acetone," National Institutes of Health, Health & Human Services. Retrieved from https://toxnet.nlm.nih.gov/cgi-bin/sis/search2/f?./temp/$\sim$feeob5:1 (accessed on 14 October 2017).

[23] American Conference of Governmental Industrial Hygienists. (2016). TLVs® and BELs® Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices. United States.

[24] Sargent, E. V. and Gallo, F. (2003). Use of personal protective equipment for respiratory protection. ILAR Journal, vol. 44, no. 1, pp. 52–56.

[25] Anderson, S. E. and Meade, B. J. (2014). Potential health effects associated with dermal exposure to occupational chemicals. Environmental Health Insights, vol. 8, no. 1, pp. 51–62.

[26] U.S. National Library of Medicine. (2014). "Isophorone Diamine," National Institutes of Health, Health & Human Services. Retrieved from https://toxnet.nlm.nih.gov/cgi-bin/sis/search2/f?./temp/$\sim$q2dkyh:1 (accessed on 14 October 2017).

[27] U.S. National Library of Medicine. (2014). "Epichlorohydrin," National Institutes of Health, Health & Human Services. Retrieved from https://toxnet.nlm.nih.gov/cgi-bin/sis/search2/f?./temp/$\sim$s3kCnp:1 (accessed on 14 October 2017.

[28] Blasche, G., Pasalic, S., Baubo ck, V.-M., et al. (2016). Effects of rest-break intention on rest-break frequency and work-related fatigue. Journal of Human Factors and Ergonomics Society, p. 0018720816671605-.

[29] National Safety Council Organization. (2017). Fatigue in the Workplace: Causes & Consequences of Employee Fatigue.