Journal of Safety Education
Volume 3 Issue 2 Year 2025 Pages 76-83

P-ISSN 2986-6391 | E-ISSN 2988-3504
https://journal.unnes.ac.id/journals/jse

Risk Level Analysis of a Compressor Equipment at Repair Shop X using HAZOP Method

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Abstract: A repair shop is a business entity operating in the field of automotive service, including vehicle repair and maintenance services, offering services ranging from routine inspections to complex damage repair. A repair shop employee is exposed to a variety of hazards, especially those related to compressor equipment, including explosion injuries, pneumatic equipment connected to a compressor, air spray, as well as respiratory illnesses. This study aims to identify and analyze the hazards that arises during works that uses a compressor at repair shop X. In this article, the researcher used a descriptive research design and the HAZOP (*Hazard and Operability Study*) approach. In the result, 4 hazards were identified in the high-risk category, 2 hazards in the medium-risk category, and 2 hazard risks in the low-risk category. In conclusion, each part of equipment or machine has different risks, but risks can be prevented through proper control.

Keywords: compressor; control; HAZOP

Submitted: March 5, 2025; **Revised**: April 16, 2025; **Accepted**: December 20, 2025

DOI: https://doi.org/10.15294/jse.v3i2.22047

INTRODUCTION

The development of the transportation sector nowadays has been growing rapidly in recent years, as people rely on motor vehicles, as shown by the data on the increasing number of motor vehicles from year to year. In 2011, there were approximately 141,9 million motor vehicles in Indonesia. The number increased to 148,2 million in 2022 (Badan Pusat Statistik, 2024), and 157,08 million in 2023 (Badan Pusat Statistik, 2024). The increasing number of motor vehicles increases the demand for repair and maintenance services. As a result, the automotive repair shop industry has grown a lot in many regions in Indonesia. Repair shop is a business unit engaged in automotive service including vehicle repair and maintenance service, providing services from regular checking to complex damage repair. As quoted from the PBOIN (*Persatuan Bengkel Otomotif Indonesia*) website, there are more than 400.000 automotive repair shops in Indonesia and 95% of it is categorized as *UMKM (Usaha Mikro, Kecil, dan Menengah*).

The business employs more than 2 million people and provides livelihood for at least 5 million people in Indonesia (Prabowo, 2024). Repair Shop X was established in 2016, located in Gajahmungkur, Semarang City. The repair shop provides various services, from vehicle maintenance to repair, and offers various vehicle spare parts. With its strategic location, repair shop X is often crowded with customers. Many activities happen every day at repair shop X. A lot of types of equipment such as compressors are very often used in many activities at repair shop X. A compressor is a machine used to compress air by pulling the air from the atmosphere or pulling air using high pressure from ambient atmospheric pressure (Siswo et al., 2022). A compressor is used in many activities such as pumping tires, operating pneumatic tools, cleaning using compressed air, and many more. Those activities make a repair shop, where mechanics do their job, have many hazard risks, which can result in accidents or illness because of work.

A work related accident refers to an incident occurring within a work environment. This includes accident that take place during travel to and from workplace. A work related illness is illness that is caused by work and/or workplace arise as a result of the job or the work environment (Peraturan Menteri Ketenagakerjaan Republik Indonesia Nomor 5 Tahun 2021 Tentang Tata Cara Penyelenggaraan Program Jaminan Kecelakaan Kerja, Jaminan

Kematian, Dan Jaminan Hari Tua, 2021). Statistics report that annually, around 250 million accidents happen and more than 160 million people getting sick, leading to 1,2 million fatalities of the workers (International Labour Organization, 2013). Both accidents and illnesses associated with work can happen because of many factors in workplace, such as physical, biological, chemical, ergonomical, and psychosocial dangers. Moreover, repair shop represents an informal sector which often lacks proper regulations and monitoring, frequently neglecting the occupational health and safety standards which are supposed to be enforced. As a result, many risks may arise whenever.

Various possible risks exist at a repair shop, particularly those associated with compressor equipment, including injuries caused by an explosion, pneumatic equipment connected to a compressor, air spray, as well as respiratory disease. Given many potential dangers arising of compressor, it is essential to identify, analyze, and mitigate the risk. One effective approach that can be used is HAZOP method (*Hazard and Operability Study*). HAZOP is a structured and systematic method to evaluate hazard risks and technical challenges when a process or system is being built or modified. This methods involves investigation to determine the likelihood of deviations from the intended design, allowing us to find whether there is any anomaly that can potentially result in adverse outcomes (Alijoyo et al., 2021). HAZOP analysis is conducted carefully, considering all potential risks associated with any part of compressor, enabling effective prevention efforts to minimize workplace injuries and.

Conducting an analysis of the hazard risk level of a compressor at a repair shop is crucial to improve workplace safety and health, which ultimately leads to improved operational efficiency. Through risk assessments, potential hazards can be identified and comprehended. Implementation of control measures also needs to be carried out as a follow-up to the analysis, such as using Personal Protective Equipment (PPE), correct implementation of Standars Operating Procedures (SOP), and educating staff about the importance of the importance of Occupational Health and Safety (OHS). These will contribute to a creation of safer and healthier working environment, for both workers and customers. The study carried out by (Lee et al., 2024) revealed a total of 21 risks, of which 9 were classified as medium risk while 12 fell into the lowrisk category. The result highlights the importance of hazard risks analysis of a compressor at a repair shop. This study focused on the HAZOP method to map the hazard risks that may arise when operating a compressor because the equipment plays a crucial role in nearly all functions within a repair shop. The objective of this research is to identify and evaluate the hazard risks of any activities associated to compressor at repair shop X.

METHODS

This study uses a descriptive research framework, where data is gathered through onsite observation and from interviews. This method involves direct investigation of the location to observe the whole working process as well as to identify potential risk that could harm employees. Other than that, interview with the people in charge of the repair shop is conducted to obtain comprehensive information and a full understanding of the necessary data (Anwar et al., 2019). The HAZOP (*Hazard and Operability Study*) method was incorporated by integrating the OHS Occupational *Risk Assessment and Control* (Pujiono et al., 2013). The primary objective for the HAZOP method is to conduct a systematic review of a process or operation in a system, which aim to detect any possible that can potentially cause accidents (Nur, 2018). The study was focused on compressor equipment at the repair shop X.

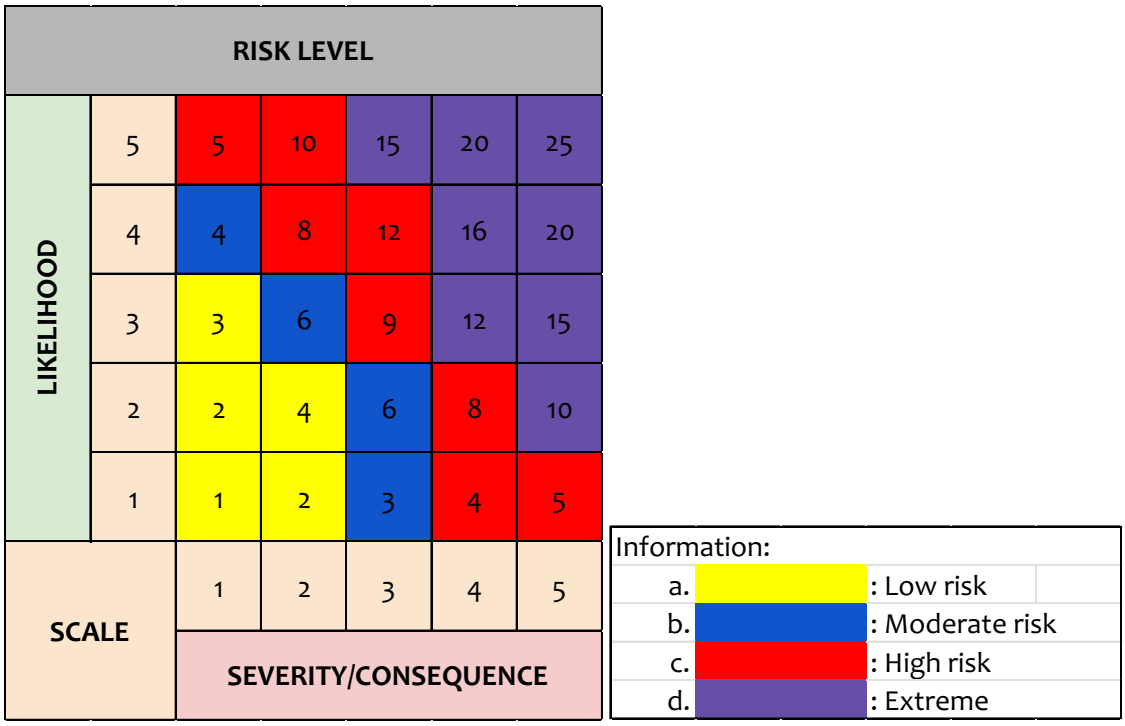
The methodology used to collect and process the data in this study involved several activities: observing repair shop X, conducting interview with the mechanics and the shop's owner, and creating a HAZOP (Hazard and Operability Study) worksheet. The HAZOP worksheet encompassed several steps: (1) identifying the sources of hazards observed (2) describing deviations observed during the work process (3) analyzing the causes of those deviations (4) identifying the potential consequences arising due to the deviations (5) performing risk assessment by defining the score of likelihood and severity criteria (6) outlining the next temporary measures to mitigate the risks (7) ranking the identified hazards potency using the HAZOP worksheet, incorporating its likelihood and severity in the risk matrix to define the hazard priority that has to be addressed first. After that, recommendations for repairs relevant to those risks were formulated (Anwar et al., 2019). Likelihood in this study refers to the estimation of how likely a potential risk to occur in the workplace as illustrated table 1. On the other hand, severity means the seriousness of the potential consequences stemming from a hazard in the workplace that can be found in table 2. (Ihromi et al., 2024).

Table 1. Likelihood

Level	Criteria	Description	
		Qualitative	Semi-quantitative
1	Rare	Not expected to occur, but still possible.	Happen less than once per 10 year.
2	Remote	Not likely to occur under normal circumstances.	Happen once per 10 year.
3	Occsaional	Possible or known to occur.	Happen once per 5 year until once per year.
4	Frequent	Common occurrence.	Happen more than once per year until once per month.
5	Almost Certain	Continued or repeating experience.	Happen more than once per month.

Table 2. Severity

Level	Criteria	Description	
		Injury Seriousness	Work Day
1	Negligible	Does not result in harm or injury to a person.	Does not result in lost of work days.
2	Minor	Result in light injuries, minor lost, and does not significantly affect someone's life.	Can still work in the same day or the same shift.
3	Moderate	Result in heavy injuries that requiring medical treatment, without causing permanent disabilities, with middle financial lost.	Result in less than 3 work days lost.
4	Major	Result in fatal injuries, permanent disabilities, large financial lost, and significantly affect the continuity of the business operation.	Result in more than 3 work days lost.
5	Catastrophic	Result in death and big loss that can permanently stop the business operation.	Result in permanent lost of work days.



Picture 1. Risk Matrix

RESULT AND DISCUSSION

When examining hazard risks using the HAZOP method, some elements such as guide words are essential to identify the deviations, while parameters serve as benchmarks for the goals of a system or process that is being analyzed. The integration of guide words and parameters allows us to identify the deviations that could occur within

a system or process, particularly at specific nodes (Vimalasari, 2016). A compressor consists of various components, such as *drain valve, fluid cooler, hose, hose fitting, ball valve, filter, pressure gauge, pressure switch, safety valve*, and *receiver tank*. From the series of compressor parts that have been directly observed, various potential hazard risks were identified. Subsequently, the research team assessed these risks using the criteria outlined in table 1 and the severity level as shown in table 2. The results were then organized into a risk matrix illustrated in picture 1., allowing for the determination of the risk level associated with any deviation observed. The findings show that if the fluid cooler part is blocked and cannot function normally, it will fail to lower the fluid temperature, resulting in excessive hot air entering the compressor. As a result, overheating occurs, which could potentially lead to an explosion. This deviation carries a total risk rating of 8 and is classified as high risk, so controlling effort is needed. The detailed result of the risk assessment are provided in details in table 3.

Table 3. Risk Assessment of Compressor Equipment at Repair Shop X

No	*Node*	Function	*Guide Word*	Parameter	Deviation	Cause	Consequences	*Risk Rating*		
								L	S	R
1	*Drain Valve*	A valve below the compressor to remove water or dirt accumulated inside the receiver tank.	*No*	*Flow*	*No flow*	Dirt is never cleaned	Accumulation of dirt, so the compressor heats up more quickly	3	1	3
2	*Fluid Cooler*	Lower the fluid temperature used to move the compressor	*More*	*Temperature*	*High temperature*	Cooler is stucked or fails, the coolant fluid is never changed	Air entering the compressor is very hot, so the pressure builds uo and overheat	2	4	8
3	*Hose*	Connecting many parts of the compressor	*More*	*Pressure*	*High pressure*	Air entering the hose is too much or too hot	Hose may be broken or air leakage happens	2	3	6
4	*Hose Fitting*	Connecting the hose with other parts of the compressor	*More*	*Pressure*	*High pressure*	Air entering the hose is too much or too hot	The hose fitting pops out	2	3	6
5	*Ball Valve*	Controlling the fluid or air flow in the compressor	*More*	*Flow*	*High flow*	Valve is opened too much so there is too much air flowing or leakage in the ball valve	Too much flow and failure in the system	2	3	6
6	*Filter*	Filtering the fluid or air entering the compressor	*No*	*Flow*	*No flow*	Dirt sticks to the filter, so the air could not go through	No air entering the compressor	3	1	3
7	*Pressure Gauge*	Measuring the air pressure	*No*	*Measure*	*No measure*	*Pressure Gauge* could not measure because of an error	Employee could not see the air pressure inside, so excess air cannot be detected	1	4	4

8	*Pressure Switch*	Maintain the compressor pressure stable and prevent damage to the other parts caused by excess pressure.	*More*	*Pressure*	*High pressure*	Pressure switch is stucked or not able to open the valve so high pressure keeps building up	It may explode or leak	1	5	5
9	*Savety Valve*	Release excess air when the pressure inside the compressor exceeds the limit to prevent damage to the compressor	*More*	*Pressure*	*High pressure*	Safety valve is stucked or fails to control the air flow going in	It may explode or leak	1	5	5
10	*Receiver Tank*	Collecting the air that has been compressed	*More*	*Pressure*	*High pressure*	Air entering the hose is too much or too hot	It may explode or leak	1	5	5

Following this, to control the hazard risk, it is essential to conduct a safeguard analysis to prevent deviation or minimize the conseqeunces caused by deviation (Risnavian, 2020). Additionally, appropriate action that is align with the control hierarchy must be implemented, such as elimination, substitution, design considerations, administration, and Personal Protective Equipment (PPE) (Singgih & Laksono, 2021). In controlling hazards associated with compressor equipment at repair shop X, only the administrative control can be applied by regularly implementing the maintenance procedures regularly, conducting inspection and checks prior to the use of the compressor, as well as conducting training for the employees. The comprehensive details of safeguard and actions to be taken are outlined in table 4.

Table 4. Control and Measures Recommentation

No	*Node*	Deviation	Cause	Consequences	*Safeguard*	*Risk Rating*	*Action*
1	*Drain Valve*	*No flow*	Dirt is never cleaned	Accumulation of dirt, so the compressor heats up more quickly	Installing filter before the valve	3	Administrative Conducting training about cleaning procedures and its consequences if it is not done properly Creating regular maintenance and cleaning schedule
2	*Fluid Cooler*	*High temperature*	Cooler is stucked or fails, the coolant fluid is never changed	Air entering the compressor is very hot, so the pressure builds uo and overheat	Adding a temperature sensor component	8	Administrative Conducting training about the importance of maintenance and the consequences due to lack of maintenance Creating a regular part checking and changing schedule
3	*Hose*	*High pressure*	Air entering the hose is too much or too hot	Hose may be broken or air leakage happens	Pressure regulator in the system	6	Administrative Implementing regular maintenance procedure properly Conducting training about potential dangers due to lack of maintenance Conducting regular inspection to ensure the condition of the part before operating

4	*Hose Fitting*	*High pressure*	Air entering the hose is too much or too hot	The hose fitting pops out	Ensuring the tightness of the hose fitting using torque wrench	6	Administrative Implementing regular maintenance procedure properly Conducting training about potential dangers due to lack of maintenance Conducting regular inspection to ensure the hose fitting's tightness
5	*Ball Valve*	*High flow*	Valve is opened too much so there is too much air flowing or leakage in the ball valve	Too much flow and failure in the system	Pressure regulator in the system	6	Administrative Implementing regular maintenance procedure properly Conducting training about potential dangers if we rotate the ball valve carelessly and exessively Conducting regular inspection to ensure the condition of the part before operating
6	*Filter*	*No flow*	Dirt sticks to the filter, so the air could not go through	No air entering the compressor	Installing pressure indicator before and after filter to detect blockage in the filter	3	Administrative Implementing regular maintenance procedure properly Conducting training about potential dangers due to lack of maintenance Conducting regular inspection to ensure the condition of the part before operating
7	*Pressure Gauge*	*No measure*	*Pressure Gauge* could not measure because of an error	Employee could not see the air pressure inside, so excess air cannot be detected	Installing secondary pressure gauge connected to the same point in the system, Using digital pressure sensor that can send data directly to the control panel	4	Administrative Implementing regular maintenance procedure properly Conducting training about potential dangers due to lack of maintenance Conducting regular inspection to ensure the condition of the part before operating

8	*Pressure Switch*	*High pressure*	Pressure switch is stucked or not able to open the valve so high pressure keeps building up	It may explode or leak	Installing pressure indicator and alarm	5	Administrative Implementing regular maintenance procedure properly Conducting training about potential dangers due to lack of maintenance Conducting regular inspection to ensure the condition of the part before operating
9	*Savety Valve*	*High pressure*	Safety valve is stucked or fails to control the air flow going in	It may explode or leak	Using PRV as an additional protection layet to prevent excess pressure	5	Administrative Implementing regular maintenance procedure properly Conducting training about potential dangers due to lack of maintenance Conducting regular inspection to ensure the condition of the part before operating
10	*Receiver Tank*	*High pressure*	Air entering the hose is too much or too hot	It may explode or leak	High pressure alarm	5	Administrative Implementing regular maintenance procedure properly Conducting training about potential dangers due to lack of maintenance Conducting regular inspection to ensure the condition of the part before operating

CONCLUSION

Compressor is made from several parts, namely drain valve, fluid cooler, hose, hose fitting, ball valve, filter, pressure gauge, pressure switch, safety valve, and receiver tank. After analyzing the parts of the compressor at repair shop X, some hazard risks were identified. Analysis was done by using HAZOP method with the node number of 10 according to the parts of the compressor. According to our analysis, 4 hazards risk are categorized into high-risk, 4 are categorized into middle-risk, and 2 are categorized into low-risk. Most of the cause that affect the hazards risk in the compressors are due to lack of monitoring and regular maintenance. Therefore, our team proposes some recommendations, including applying of regular maintenance procedures, chek-up or regular inspection before the compressor is used, and conducting training for the workers, to improve the knowledge and awareness of the importance of Health and Safety in the Workspace.

DECLARATION OF GENERATIVE AI

The authors declare that no generative AI or AI-assisted technologies were used in the writing process of this manuscript.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

FUNDING STATEMENT

This research received no external funding.

REFERENCES

Alijoyo, A., Wijaya, B., & Jacob, I. (2021). *A Hazard and Operability Studies*. CRMS. https://lspmks.co.id/wp-content/uploads/2021/01/A-Hazard-and-Operability-Studies.pdf

Anwar, C., Tambunan, W., & Gunawan, S. (2019). Analisis kesehatan dan keselamatan kerja (K3) dengan metode hazard and operability study (HAZOP). *Jurnal Teknik Mesin Dan Mekatronika (Journal of Mechanical Engineering and Mechatronics)*, *4*(2), 61–70. http://e-journal.president.ac.id/presunivojs/index.php/JMEM/article/view/825

Badan Pusat Statistik. (2024a). *Jumlah Kendaraan Bermotor Menurut Provinsi dan Jenis Kendaraan (unit), 2023*.

Badan Pusat Statistik. (2024b). *Perkembangan Jumlah Kendaraan Bermotor Menurut Jenis (Unit), 2021-2022*.

Ihromi, W. D., Putri, A. W., Safitri, D., Dewi, N. M. A. A., & Anwar, P. P. (2024). IDENTIFIKASI RISIKOPADA UDLAKSANA JAYA BORDIRDENGAN METODE HAZARD AND OPERABILITY STUDY (HAZOP). *Jurnal Ekonomi, Manajemen Dan Akuntansi*, *2*(5), 42–57.

International Labour Organization. (2013). *Keselamatan dan Kesehatan Kerja Sarana untuk Produktivitas*. International Labour Office.

Lee, S., Kim, M., Kim, D., Byeon, B., Kim, K., Jeong-hoon, K., Sang-yoon, L., Hyo-byeong, C., Jin-wook, K., & Geun-tae, L. (2024). 상용급 수소액화 플랜트 압축기 테스트베드의 HAZID/HAZOP 위험성평가에 관한 연구. *Journal of the Korean Institute of Gas*, *28*(3), 105–116.

Nur, M. (2018). Analisis Keselamatan dan Kesehatan Kerja Menggunakan Metode Hazard and Operability Study (HAZOP) Di PT. XYZ. *Jurnal Hasil Penelitian Dan Karya Ilmiah Dalam Bidang Teknik Industri*, *4*(2), 133–138. https://ejournal.uin-suska.ac.id/index.php/jti/article/view/6627

Peraturan Menteri Ketenagakerjaan Republik Indonesia Nomor 5 Tahun 2021 Tentang Tata Cara Penyelenggaraan Program Jaminan Kecelakaan Kerja, Jaminan Kematian, Dan Jaminan Hari Tua, 5 (2021). https://peraturan.bpk.go.id/Details/195976/permenaker-no-5-tahun-2021

Prabowo, H. E. (2024). *Welcome to The Association of Indonesia Automotive Repair shop – PBOIN*. https://www.pboin.or.id/

Pujiono, B. N., Tama, I. P., & Efranto, R. Y. (2013). Analisis Potensi Bahaya Serta Rekomendasi Perbaikan Dengan Metode Hazard and Operability Study (HAZOP) Melalui Perangkingan OHS Risk Assessment and Control (Studi Kasus: Area PM-1 PT. Ekamas Fortuna). *Jurnal Rekayasa Dan Manajemen Sistem Industri*, *1*(2), 253–264.

Risnavian, A. D. R. (2020). *STUDI HAZOP DAN VERIFIKASI SAFETY INTEGRITY LEVEL (SIL) FUEL GAS SYSTEM PADA ONSHORE RECEIVING FACILITIES (ORF) DENGAN STANDAR IEC 61511 DAN METODE FAULT TREE ANALYSIS (FTA)* [Institut Teknologi Sepuluh Nopember]. https://repository.its.ac.id/80426/1/04211640000023-Undergraduate_Thesis.pdf

Singgih, K. M. N. A., & Laksono, M. (2021). Pengendalian Risiko Kecelakaan HSSE pada Proses Pembuatan Pipa Baja. *JURNAL TEKNIK ITS*, *10*(2), B52–B57. https://media.neliti.com/media/publications/504824-none-06b163c2.pdf

Siswo, M., Subekti, J., Purwantono, Astriawati, N., & Setiyantara, Y. (2022). UPAYA PERAWATAN KOMPRESOR UDARA DUA TINGKAT UNTUK MENGHASILKAN UDARA BERTEKANAN TINGGIDIKAPAL KM. SK3. *Jurnal Sains Teknologi Transportasi Maritim*, *4*(2), 21–27. https://jurnal.akmicirebon.ac.id/index.php/akmi/article/view/54/44

Vimalasari, T. (2016). *HAZARD AND OPERABILITY STUDY (HAZOP) AND SAFETY INTEGRITY LEVEL (SIL) DETERMINATION IN BOILER SB-02 PT. SMART Tbk SURABAYA* [Institut Teknologi Sepuluh Nopember]. https://repository.its.ac.id/41888/1/2412100011-Undergraduate-Theses.pdf