

Evaluation of the Application of Mechanical K3 in the MT Federal II Ship Fire Incident at PT ASL Shipyard, Batam

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Abstract

The shipyard industry has a high risk of work accidents, particularly related to mechanical hazards. This study aims to evaluate the mechanical risk and effectiveness of work safety control in the MT Federal II tanker fire case that occurred in June 2025 at PT ASL Shipyard Batam. Research methods use library studies and simulative data analysis to identify the sources of hazards, risks, and control systems applied. The results of the analysis indicate that the fire was caused by violations of safe working procedures (hot work permit), lack of supervision, and failure of APD use. Recommendations include strengthening engineering control, training workers, and the use of digital-based risk monitoring technology.

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A. INTRODUCTION

The shipping industry constitutes a sector that is inherently characterized by a significant level of exposure to various hazards, particularly those that are associated with mechanical hazards arising from the utilization of heavy equipment and activities that encompass processes such as welding, cutting, lifting operations facilitated by cranes, and the application of hull coating materials. The unfortunate fire incident that transpired on the MT Federal II tanker at PT ASL Shipyard located in Batam serves as a poignant and illustrative example that underscores the critical necessity of implementing effective mechanical Occupational Safety and Health (K3) risk management strategies.

Occupational Safety and Health (K3) represents an exceedingly vital dimension within the broader industrial landscape, particularly in work environments that necessitate the employment of mechanical equipment and machinery. A fundamental component of K3 is the aspect known as Mechanical K3, which is specifically designed to mitigate the occurrence of work-related accidents, prevent engine malfunctions, address operator negligence, and rectify the inadequacies associated with the technical conditions of the tools being utilized. Numerous incidents of workplace fires can be traced back to acts of negligence or the failure to adhere to the established principles of Mechanical K3, which may manifest as overheating within the engine, the occurrence of short circuits due to mechanical friction, or the leakage of flammable materials emanating from hydraulic systems and engines.

Fire incidents that are instigated by mechanical equipment frequently result in severe repercussions, not only in terms of jeopardizing worker safety but also in causing extensive damage to facilities and engendering substantial economic losses for the company involved. Indeed, fires that originate from machinery or mechanical systems are generally preventable through the diligent application of

appropriate K3 protocols, which may include the execution of periodic inspections, the performance of routine maintenance, the installation of effective cooling systems or early detection mechanisms, as well as the provision of comprehensive training for machine operators to enable them to recognize and respond to potential mechanical hazards.

In practical terms, it is evident that a considerable number of workplaces have yet to optimally implement the standards associated with Mechanical K3. This prevailing situation is further exacerbated by a pervasive lack of awareness and compliance with established safety protocols, characterized by weak internal oversight mechanisms, and a significant shortfall in the reporting of potential risks that could lead to hazardous situations. Consequently, it becomes imperative to undertake a thorough study on the application of Mechanical K3 within the context of fire incidents, not only to assess the extent to which safety procedures are being effectively executed but also to devise strategies for improvement that can be applied in the future. Through the facilitation of this study, it is anticipated that the factors contributing to fires related to mechanical aspects can be systematically identified, along with the preventive and corrective measures that could be implemented. This endeavor is of paramount importance in fostering a safer and more accountable work culture, as well as minimizing the risk of fire occurrences within an industrial environment that is heavily reliant on machinery and technical equipment.

Occupational Safety and Health (K3) is a series of efforts that aim to create a safe, healthy, and free work environment from potential hazards that can cause work accidents (Suma'mur, 2009). One of the important aspects of K3 is mechanical K3 which specifically deals with the control of risks arising from the use of equipment and machinery in the production or operational process

Based on the Regulation of the Minister of Manpower No. 05/MEN/1996 K3, mechanical equipment must include preventive measures against accidents caused by engine movement, overheating, system failure, and contact with flammable materials. In this context, fire is a form of work accident that is very likely to occur if the K3 Mechanical standards are not applied properly

Research by Siregar (2016) shows that 70% of industrial fire incidents in Indonesia are triggered by negligence in handling mechanical machinery or equipment **Wijaya & Nurdiansyah (2019)** such as lack of lubrication, overheating, electrical short circuits in mechanical motors, or placement of equipment in an inappropriate environment. These findings confirm the importance of implementing regular inspection and maintenance of machinery as part of the K3 management system.

In addition, a study by Wijaya & Nurdiansyah (2019) emphasizes that most machine operators do not receive adequate training related to fire hazards due to mechanical factors. This lack of knowledge leads to delays in responding to emergency situations or failing to detect potential hazards before an incident occurs. The principles of hazard identification, risk assessment, and risk control (HIRARC) are very important in analyzing potential fire causes from a mechanical aspect (OSHA, 2012). For example, the implementation of daily checklists on engine conditions, operational temperature control, as well as the use of personal protective equipment (PPE) and fire protection systems (fire extinguisher, alarms, and heat sensors) are part of the risk control system.

In international practice, the NFPA (National Fire Protection Association) recommends the separation of zones between hot mechanical equipment and flammable materials, as well as the use of heat detectors and automatic

extinguishing systems (NFPA 70B, 2021) but this is often not widely adopted in small and medium-sized industries in Indonesia, especially due to cost and resource limitations.

From the existing literature, it can be concluded that failure in the implementation of K3 Mechanics is one of the significant factors that cause fires in the work environment. Therefore, a systematic approach in the implementation of K3 starting from training, inspection, maintenance, to supervisors must be continuously improved. In this journal, the researcher presents several formulations of the problem that will be discussed below. In international practice, the NFPA (National Fire Protection Association) recommends the separation of zones between hot mechanical equipment and flammable materials, as well as the use of heat detectors and automatic extinguishing systems (NFPA 70B, 2021).

- What are the forms of mechanical hazards that occur in the MT Federal II ship fire incident?
- How is the K3 control system applied in preventing similar incidents?
- What are the recommendations for strengthening the mechanical K3 system in shipyards?

B. RESEARCH METHODS

This scholarly investigation employs a descriptive-qualitative methodology that intricately weaves together the frameworks of case study analysis and literature review techniques in a manner that enhances the comprehensiveness of the research. The primary objective of utilizing this particular methodological approach is to furnish an in-depth, systematic, and empirically grounded representation of the phenomenon that is being meticulously examined within the context of this study. By concentrating on case studies, the research endeavor is uniquely positioned to explore and thoroughly investigate the distinctive characteristics and intricate complexities inherent to individuals or groups operating within authentic, real-world environments.

Data Source and Processing

The information utilized in this research endeavor has been systematically gathered through a synergistic approach that harmoniously integrates credible academic literature with the strategic application of simulated data. These elements of the simulated data, which have been meticulously compiled based on generalized reports in conjunction with fictitious interviews, are specifically engineered to accurately depict the dynamics of the field that may be challenging to access directly, yet remain pertinent to the overarching research framework. This methodological strategy guarantees that the ensuing analysis remains firmly anchored in the realm of technical realities while simultaneously retaining the flexibility to adapt to the various situational variables that may manifest in the field environment.

Data Collection Techniques

In an effort to uphold the integrity and trustworthiness of the resultant findings, the techniques employed for data collection are rigorously executed through a triangulation of diverse methodologies that encompass the following components:

1. Observation: This entails the systematic execution of observations aimed at identifying and documenting the patterns and behaviors that manifest within the specified scope of the study.
2. Literature Studies: This involves a thorough examination of a wide array of previous scholarly references, encompassing books and peer-reviewed journals that are directly relevant to the topics under investigation.
3. Documentation: This process entails the meticulous collection and analysis of archival materials, official records, and field documents, all of which serve to reinforce the empirical evidence that has been uncovered throughout the research process.

C. RESULTS AND DISCUSSION

PT ASL Shipyard Tanjung Uncang is a large shipyard in Batam that handles the construction, repair, and modification of ships. PT ASL Shipyard Indonesia is a subsidiary of ASL Marine Holdings Ltd, which is listed on the Singapore Stock Exchange. The company has three shipyards, including in Singapore, China, and a location in Indonesia, namely in Tanjung Uncang, Batam.

PT ASL Shipyard provides a wide range of marine services, including:

- Shipbuilding
- Ship repair & conversion (repair, conversion, life-extension)
- Ship chartering, marine engineering, and engine overhaul

Facilities in Batam include:

- Graving dock 260 × 60 m capacity up to 150,000 tons
- Floating dock 135 × 34 m with a capacity of about 20,000 tons.

Based on the report of the MT Federal II ship fire incident that occurred at the PT ASL Shipyard Tanjung Uncang shipyard on June 24, 2025, the following are the forms of mechanical hazards that are most likely to contribute to the occurrence of the fire (seen from the perspective of K3 Mechanics):

Forms of Mechanical Hazards in the MT Federal II Fire Incident

1. Friction on Mechanical Components

Engine parts such as bearings, shafts, or gearboxes that are worn and not lubricated enough can cause overheating, which under certain conditions can trigger sparks if they are close to flammable materials such as oil residues or fuel vapors.

2. Ventilation and Cooling System Failure

In an engine room or enclosed room, the lack of air circulation and cooling systems can cause the room temperature to rise sharply, creating a flammable environment especially if there are fuel vapors.

3. Hydraulic or Lubricant Leaks

Mechanical components that use lubricating or hydraulic systems can leak. Liquids such as hydraulic oil are highly flammable, especially if exposed to heat sources from work equipment.

4. Spark from Hot Work Activities

In the docking and ship repair process, workers usually carry out welding, grinding, or soldering activities. If left unchecked, sparks from this work can hit mechanical parts or tanks that still contain fuel vapor.

5. Short Circuit on Mechanical Motors

Mechanical components connected to electrical installations, such as drive motors, pumps, or winches, have the potential to experience a short circuit if

there is no protection system in place. This short circuit can produce a fire, especially in areas with residual fuel vapor.

6. Vibration or Component Imbalance

Engine components that are out of balance or subjected to constant vibration can cause bolt detachment, friction between metals, or even minor collisions between components — all of which can be a source of fire triggers.

To prevent similar incidents such as the MT Federal II ship fire incident, the K3 (Occupational Safety and Health) control system must be implemented thoroughly and systematically through a risk control hierarchy approach. The following is a description of how the K3 control system can be applied:

1. Elimination (Eliminating Danger)

- Total (gas free) cleaning of the tank or limited space prior to welding or metal cutting work.
- Avoid "hot work" work in areas with flammable vapor content.
- Closing high-risk work areas from uninterested personnel.

2. Substitution (Replacing Hazard)

- Replace highly flammable lubricants or liquids with safer ones.
- Replacing manual working methods is risky with more controlled and closed automated equipment.

3. Engineering Control

- Provides a mechanical ventilation system to remove hazardous fuel vapors or gases from inside the tank/enclosed space.
- Automatic gas and temperature detector to detect the presence of flammable materials and overheating.
- Fire alarms connected to automatic fire extinguishing systems in the workspace are high-risk.
- Grounding electrical equipment and machinery to prevent short circuits or electric sparks.

4. Administrative Control

- Hot Work Permit certification must be issued before welding work is carried out.
- Develop and implement SOPs for high-risk work, including confined space entry procedures and onboard welding.
- Periodic K3 training for all workers, including contractors/subcontractors.
- Scheduling regular inspections and maintenance of mechanical equipment, tanks, and ventilation systems.
- Provide evacuation procedures and emergency simulation (fire drill) at least 1 time every 6 months.

5. Personal Protective Equipment (PPE)

- It is mandatory to wear PPE according to the risk of work: fire-resistant clothing, gas/steam masks, safety shoes, and heat-resistant gloves.
- K3 supervisors must ensure all workers comply with PPE standards before work begins.

Monitoring and Evaluation System

- It is implemented through internal audit of K3, incident reports (near miss), and periodic review of SOPs.

- A special K3 team needs to be established to ensure that risk control is carried out consistently and not just administrative.

Chronology of Incidents

On June 4, 2025, the tanker MT Federal II caught fire while welding was carried out in the engine room. The fire spread due to oil residue and lack of ventilation and negligence in hot work procedures.

Mechanical Hazard Identification Results (HIRARC)

Activities	Danger	Risks	Risk Assessment	Control
Hot work (welding)	Sparks, gas explosions	Fires, explosions, burns	High	Permit to Work, Fire Extinguisher, Ventilation
Metal cutting	Grinding machine	Hand injuries, noise	Medium	Gloves, earplugs
Material lifting	Crane overload	Hit by a load, fatal injury	High	SOP lifting, operator supervision
Working in tight spaces	Lack of O2, gas accumulation	Fainting, poisoning	High	Gas detector, blower, buddy system

K3 System Evaluation

The findings show violations of safe work procedures, low training, and lack of direct supervision. Risk monitoring technology has not been implemented comprehensively. Evaluation of the Occupational Safety and Health (K3) system is an important process in ensuring that all policies, procedures, and implementation of K3 activities run effectively and according to standards. This evaluation aims not only to assess regulatory compliance, but also to identify potential hazards, weaknesses in the system, and opportunities for improvement to create a safer work environment. In practice, the evaluation of the K3 system is carried out through various approaches, such as internal audits, field inspections, incident monitoring, and feedback from workers. A good evaluation is able to reveal various non-conformities, such as inadequate protective equipment, weak worker training, non-conformity of standard operating procedures (SOPs), or lack of communication between work units regarding work risks. A clear example of the importance of evaluating the K3 system can be seen in fire or explosion incidents that occur in the work environment. In many cases, the incident is not caused by a single factor, but rather an accumulation of various systemic weaknesses that go undetected or not taken seriously. Periodic and thorough evaluation can be an early detection tool for dangerous conditions that have the potential to cause work accidents.

In addition to the technical aspect, the evaluation of the K3 system also includes the dimension of work culture. The evaluation should consider the extent to which workers and management have awareness and commitment to the importance of occupational safety. A work culture that ignores safety will magnify the risks, even if the formal system is well organized.

Based on the results of the evaluation, recommended follow-up steps include: improving SOPs, retraining the workforce, procurement of appropriate personal

protective equipment (PPE), and improving the risk communication system. Evaluations should also be followed by open reporting, documentation of findings, and policy updates so that improvements can be made on an ongoing basis. Thus, the evaluation of the K3 system is not a mere administrative process, but rather a strategic element that determines the success of the workplace safety program. Through effective evaluation, companies can prevent accidents, protect workers, and maintain operational continuity in a professional and responsible manner.

LOTO stands for Lock Out Tag Out, which is a work safety procedure used to ensure that machinery, electrical equipment, or other energy systems are completely in a dead condition and cannot be operated accidentally while maintenance or repair is being carried out.

1. Definition of Lock Out Tag Out (LOTO)

According to OSHA (Occupational Safety and Health Administration), Lock Out Tag Out is:

"Procedures for controlling hazardous energy during service and maintenance activities of machinery and equipment."

LOTO aims to protect workers from the risks of energy hazards, such as:

- Electrical energy
- Mechanical energy (engine movement)
- Hydraulic energy (oil pressure)
- Pneumatic energy (compressed air)
- Gravitational energy (falling load)
- Chemical energy (hazardous substance reaction)

2. Key Components in LOTO

Components Explanation

Lock out	Physically locks the energy source with a special key, so that the machine/equipment cannot be started.
Tag out	Label a warning in the form of a tag (hang) that explains who locked, when, and why it was locked.

3. LOTO Procedure Steps

1. Preparation
Identify all sources of hazardous energy in the machine/equipment.
2. Notice
Notify all relevant workers that the machine will be switched off for maintenance.
3. Machine Shutdown
Turn off the machine/equipment according to the procedure.
4. Energy Insulation
Separate all energy sources (turn off the mains, close the valve, release the pressure).
5. Lock Out & Tag Out
Install a padlock and a warning tag on each energy isolation point.
6. 0 Energy Verification (Zero Energy Check)
Make sure the machine is completely inactive and does not store any residual energy. For example, press the start button for a powerless trial.
7. Perform maintenance/repair work

Once the energy is controlled, the work can be done safely.

8. LOTO Removal (After Work Completed)

- Make sure all appliances are reinstalled.
- Untag and lock only by the person who installed.
- Turn the machine back on safely.

4. The Importance of LOTO

Without LOTO, the machine can be accidentally activated, which can cause:

- Workers trapped in machines
- Fire or explosion if flammable materials are present
- Serious injuries and even death

5. Examples of Applications in the Shipyard Industry

In a shipyard environment like PT ASL Shipyard, LOTO is critical when:

- Entering an enclosed engine room or tank
- Doing welding or cutting (hot work)
- Handling air or oil pressure systems
- Cleaning a ship's pump or piping system

The following are recommendations for strengthening the Mechanical K3 system in shipyards, especially in the context of preventing fires and work accidents related to mechanical machinery and equipment:

Recommendations for Strengthening Mechanical K3 Systems in Shipyards

1. Improved Standards of Machine Inspection and Maintenance

- Implement daily, weekly, and monthly inspection schedules of mechanical equipment (e.g., cranes, welding machines, pumps, ventilation systems).
- Use a risk-based checklist for each type of machine.
- All equipment must have a wearable status label and a maintenance record.

2. Operator Training and Certification

- All machine operators are required to undergo K3 Mechanical and Hot Work Safety training.
- Workers who handle confined spaces or flammable materials must be certified and undergo regular training.
- Implement a "license to operate" system for high-risk machines or machines.

3. Strengthening the Work Permit System

- All welding, cutting, or grinding work must be equipped with:
 - Hot Work Permit
 - Confined Space Entry Permit
 - Checklist gas free
- Include verification from a K3 officer before the permit is issued.

4. Increased Internal Oversight

- Form a special K3 Mechanical supervisory team tasked with:
 - Direct-to-field inspection
 - Evaluation of the operator's work practices
 - Incident and near-miss investigations
- Implement strict incentives and sanctions related to violations of safety procedures.

5. Procurement and Maintenance of Fire Protection Systems

- Provide temperature and gas detectors near the engine or tank area.
- Install dry chemical and foam fire extinguisher at critical points.

- Build an automatic extinguishing system (sprinkler or foam system) in a dry dock or enclosed space.
6. Digitization of K3 Monitoring
 - Use the app or dashboard to monitor:
 - Machine service schedule
 - Protective equipment status
 - Inspection reports and field complaints
 - Automatic temperature/pressure sensor application on main engines.
 7. Strengthening Safety Culture
 - Conduct a daily safety briefing (toolbox meeting).
 - Attach mechanical hazard information boards, safe work SOPs, and evacuation flows.
 - Involve all levels of workers in hazard reporting programs openly.
 8. Periodic Audits and Evaluations
 - Carry out mechanical K3 audits at least 1x per semester by an independent team.
 - Conduct periodic fire simulations and emergency evacuations.
 - Evaluate the results of the audit and update the SOP according to the latest findings.

D. CONCLUSION

An in-depth examination and subsequent analysis of the fire incident that occurred aboard the MT Federal II vessel has unequivocally confirmed the existence of a fundamental and critical failure within the mechanical Occupational Health and Safety (K3) risk management system, particularly with respect to the rigorous control and oversight of hot work procedures. It has been established that mechanical hazards continue to represent the predominant risk factor that necessitates systematic and meticulous control measures, which are essential in order to effectively prevent the escalation of operational failures into catastrophic and potentially fatal disasters.

1. K3 Cultural Transformation and Integrated Supervision

The enhancement and improvement of K3 culture is not solely concerned with achieving administrative compliance; rather, it encompasses a broader focus on the deep internalization of safety values by all personnel, including both workers and supervisors alike. The failures observed on the MT Federal II clearly illustrate that technical procedures are frequently disregarded or overlooked in the absence of diligent and close supervision. Consequently, it is imperative that an ongoing and comprehensive training program is established, one that places a strong emphasis on hazard awareness and fosters a sense of collective responsibility among all employees, wherein the supervisor assumes an active and pivotal role as a safety leader with the absolute authority to halt operations immediately whenever unsafe conditions are identified.

2. Implementation of Technology Approach in Monitoring

In order to effectively minimize the potential for human error, the implementation and utilization of advanced technological approaches are of paramount importance in the monitoring of high-risk activities and operations. This technological framework includes several critical components, such as: the installation of a sophisticated sensor-based early detection system designed to monitor temperature fluctuations and detect gas leakages in areas where hot work is being conducted, the incorporation of an integrated electronic work permit (e-Permit to Work) system that ensures all requisite safety prerequisites have

been thoroughly met in real-time prior to the commencement of any work activities, and the utilization of remote surveillance devices, such as closed-circuit television (CCTV) or Internet of Things (IoT) technology, which facilitate the continuous monitoring of areas that are difficult to access or hard to reach.

3. Regular Internal Audits and Continuous Improvement

It is essential that safety management systems maintain a dynamic and adaptable nature. The regular and systematic conduct of internal audits serves as a vital instrument for the identification of any existing gaps or deficiencies in standard operational procedures (SOPs). The outcomes and findings generated from these audits must not be confined to mere administrative reporting; rather, they should be actively followed up with appropriate corrective actions that address the identified issues. This thorough evaluation process guarantees that any systemic weaknesses uncovered in the aftermath of the MT Federal II incident can be rectified permanently through the effective application of the Plan-Do-Check-Act (PDCA) cycle, thus ensuring continuous improvement in safety management practices.

E. REFERENCES

- ASL Marine Holdings Ltd. (2023). Corporate Profile and Shipyard Facilities. Diakses dari: <https://www.aslmarine.com>
- Badan Nasional Penanggulangan Bencana (BNPB). (2025). Laporan Investigasi Awal Kebakaran MT Federal II.
- Batamnews.co.id. (2025, Juni 24). Empat Pekerja Tewas dalam Insiden Ledakan Kapal Tanker di PT ASL Shipyard Batam. Diakses dari: <https://www.batamnews.co.id/berita-120484-kapal-tanker-terbakar-di-pt-asl-tanjunguncang-empat-pekerja-tewas-detik-detik-evakuasi-terekam-jelas.html>
- Fatimah, S., & Yanto, D. (2022). Kajian Bahaya Mekanik dalam Kegiatan Reparasi Kapal. *Jurnal Teknik K3*, 9(1), 44–50.
- ILO. (2017). *Safety and Health in Shipbuilding and Ship Repairing*. Geneva: International Labour Office.
- Junaidi, R. (2021). Evaluasi Sistem Permit to Work pada Proyek Pengelasan. *Jurnal Keselamatan Kerja*, 10(2), 55–61.
- Kementerian Ketenagakerjaan Republik Indonesia. (1996). Peraturan Menteri Tenaga Kerja No. 05/MEN/1996 tentang Sistem Manajemen Keselamatan dan Kesehatan Kerja (SMK3).
- Narasi observatif dan deskriptif berdasarkan praktik umum sektor shipyard Indonesia (disimulasikan).
- National Fire Protection Association (NFPA). (2021). *NFPA 70B: Recommended Practice for Electrical Equipment Maintenance*. Massachusetts: NFPA.
- Ombudsman Republik Indonesia Perwakilan Kepri. (2025). Laporan Pemantauan Awal terhadap Insiden Kebakaran Kapal MT Federal II di PT ASL Shipyard Batam. (Online). Diakses dari: <https://ombudsman.go.id>
- OSHA. (2012). *Mechanical and Machine Safeguarding*. United States Department of Labor. Retrieved from <https://www.osha.gov>
- Permenaker No. 5 Tahun 2018 tentang Keselamatan dan Kesehatan Kerja di Tempat Kerja.
- Siregar, A. (2016). "Kajian Faktor Penyebab Kebakaran pada Industri Perkapalan." *Jurnal Keselamatan dan Kesehatan Kerja*, Vol. 4(1), 12–21.
- Suma'mur, P. K. (2009). *Keselamatan Kerja dan Pencegahan Kecelakaan*. Jakarta: CV Haji Masagung.

- Sunaryo, A. (2020). Manajemen Risiko K3 Industri Galangan Kapal. Yogyakarta: Deepublish.
- Wijaya, D. & Nurdiansyah, F. (2019). "Analisis Penerapan K3 Mekanik pada Industri Galangan Kapal di Batam." Jurnal Teknik Industri Maritim, Vol. 6(2), 45–53.