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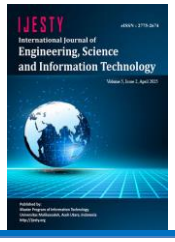

Integrating Fire Prevention Strategies with Industrial Hygiene to Enhance Workplace Safety in Textile Industries

Bekti Utomo

Industrial Hygiene Research Group, Universitas Sebelas Maret, Indonesia

**Corresponding author Email: mr.bektiutomo@staff.uns.ac.id*

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Abstract

The textile industry in Indonesia is an economic sector that contributes significantly to exports and employment but has serious challenges related to occupational safety and health (OHS), especially in fire prevention and industrial hygiene. This study aims to analyze integrating fire prevention strategies with industrial hygiene practices to improve occupational safety in the textile sector. The method used is a case study of several textile companies in Indonesia with an analysis of the implementation of OHS policies, fire control technology, and its impact on worker safety. The results showed that companies implementing an integrated OHS management system experienced fewer fire incidents and safer working conditions. Key factors supporting this success include utilizing automatic fire detection technology, improved ventilation, and safety training for workers. In addition, government regulations and company management's awareness of adopting occupational safety standards play an essential role in the effectiveness of OHS programs. In conclusion, integrating fire prevention strategies with industrial hygiene is critical for improving occupational safety and health in Indonesia's textile industry. Recommendations include strengthening company policies, improving workforce training, and utilizing modern fire risk management and industrial hygiene technology. The findings are expected to contribute to developing more effective and sustainable OHS policies in the national textile industry.

Keywords: *Occupational Safety and Health, Fire Prevention, Textile Company, Industrial Hygiene.*

1. Introduction

The textile industry in Indonesia has long been one of the key sectors in the national economy, with significant contributions to exports and employment. However, the industry also has serious challenges related to occupational safety and health (OHS), particularly fire risks and exposure to various industrial hazards. Therefore, integrating fire prevention strategies with industrial hygiene practices is crucial to creating a safe and productive work environment [1]. Fire is one of the main threats in the textile industry. Data shows that in 2012 to 2014, PT Asia Pacific Fibers, Tbk experienced several fire incidents in the Spinning unit, which caused material losses and threatened the safety of workers [2]. Factors causing fires in the textile industry include weak fire safety management, the accumulation of flammable textile fibres, and electrical installations that do not meet standards [3].

In addition to the risk of fire, workers in the textile industry are also exposed to various health hazards due to unhygienic working environments. Exposure to cotton dust, for example, can cause respiratory diseases such as bicinosis [4]. Working conditions with poor ventilation and high temperatures also contribute to the deterioration of workers' health. Effective implementation of industrial hygiene involves identifying and controlling environmental factors that can negatively impact worker health. Measures such as dust control, improved ventilation systems, and air quality monitoring are integral to these efforts [5]. However, industrial hygiene efforts may not be sufficient to ensure overall safety without integration with fire prevention strategies.

The integration of fire prevention and industrial hygiene strategies requires a comprehensive approach. This includes a thorough risk assessment, implementation of technical controls such as installing smoke detectors and sprinkler systems, and administrative controls through regular worker training [6]. In addition, the use of appropriate personal protective equipment (PPE) is also an essential component in protecting workers from fire hazards and exposure to hazardous substances. A case study at PT Paberik Tekstil Kasrie revealed that in the last five years, the company experienced 20 workplace accident incidents, with 14 of them being fires [7]. This data

emphasizes the urgency of implementing an integrated OHS management system, which focuses on fire prevention and controlling industrial hygiene factors.

The Indonesian government has issued various regulations to support the implementation of OSH in industry, including the Minister of Manpower Regulation No. 5 Year 1996 on Occupational Safety and Health Management System. However, implementation in the field often faces obstacles, such as a lack of awareness of management and workers and limited resources [8]. Previous research shows that effective implementation of fire planning management can increase workers' sense of safety in textile factories [9]. In addition, an evaluation of industrial hygiene and sanitation implementation at PT Croda Indonesia emphasized the importance of identifying sources of hazards and implementing appropriate control measures [10].

Effective integration between fire prevention and industrial hygiene requires commitment from all parties, from top management to front-line workers. Continuous training and education are key to building a workplace safety culture. In addition, collaboration with an Occupational Safety and Health Service Company (OSHSP) can assist companies in identifying risks and designing appropriate control strategies [11]. In the context of globalization and intensifying industrial competition, implementing high OHS standards protects workers and enhances the company's reputation. Companies that proactively manage OHS risks tend to have better operational performance and are more favoured by business partners and consumers [12]. In recent years, the increasing number of fires in the textile industry sector in Indonesia indicates the need for more effective strategies in risk mitigation. Data from the Ministry of Manpower (2023) noted that as many as 35% of the total work accidents in the manufacturing sector came from fires in textile factories. This high number indicates that the prevention measures implemented so far are still not optimal, so better integration between fire prevention strategies and industrial hygiene is needed to create a safer and healthier work environment.

In addition, challenges in implementing OHS systems in the textile industry are also caused by a lack of understanding and compliance with existing regulations. Research shows that only 60% of textile companies in Indonesia have thoroughly implemented occupational safety standards [12]. This is exacerbated by workers' low awareness of the importance of preventive measures, such as using personal protective equipment (PPE) and reporting potential hazards in the workplace. Therefore, a training and education-based approach is needed to increase workers' and company management's awareness and compliance with OHS standards. From an economic perspective, implementing a sound OHS system can also provide benefits to companies in the long term. Research shows that companies that invest funds in OHS management systems experience a 20% increase in productivity and a 30% decrease in costs due to work accidents [13]. Thus, integrating fire prevention and industrial hygiene strategies aims to protect the workforce and improve the operational efficiency and competitiveness of textile companies in Indonesia.

However, the challenges in implementing this integration cannot be ignored. Some companies face budget constraints, a lack of OHS experts, and resistance to changes in work culture. Therefore, a phased approach tailored to the company's specific conditions is a realistic strategy [14]. In addition, companies need to conduct regular OHS evaluations and audits. This aims to ensure that the system that has been implemented is effective and to make improvements if weaknesses are found. Modern technologies, such as automatic fire detection systems and real-time air quality monitoring, can be a valuable investment in this endeavour [13]. In addition, further research is needed to identify the best methods for efficiently integrating fire prevention and industrial hygiene strategies. More in-depth studies can help develop evidence-based policies that can be applied across different textile industries in Indonesia. Thus, the results of this study are expected to provide strategic recommendations for stakeholders to improve occupational safety and health standards in the national textile sector.

2. Methods

This research uses a qualitative approach with a case study method to analyze the integration of fire prevention and industrial hygiene strategies in improving occupational safety in the textile industry in Indonesia. Case studies were chosen because they allow researchers to explore the implementation of safety policies and practices in several textile companies in depth. Data were collected through in-depth interviews with OHS managers, workers, and other relevant parties and through direct observation at the textile industry sites. In addition, this study also used document analysis to review applicable regulations and company policies related to occupational safety and industrial hygiene. Some of the documents analyzed include work accident reports, standard operating procedures (SOPs) related to fire prevention, and occupational safety and health (OHS) audit documents from textile companies that are the study's sample. This data was used to understand the extent to which safety regulations and standards have been implemented in the field.

To increase the validity and reliability of the data, this study applied triangulation techniques by comparing the results of interviews, observations, and document analysis. This approach ensures that multiple data sources support the research findings to provide a more comprehensive picture of the effectiveness of integrating fire prevention and industrial hygiene strategies in the textile industry. The data obtained were analyzed using the thematic analysis method, in which the data were categorized based on key themes such as OHS policies, implementation of fire prevention systems, industrial hygiene factors, and challenges in implementing occupational safety strategies. Furthermore, the analysis was conducted to identify patterns, relationships, and factors that support or hinder the successful integration of the two techniques in the textile industry.

The results of this study are expected to provide policy recommendations for textile companies in improving work safety standards and assist regulators in designing more effective policies. Thus, this research is not only academic but also has practical implications in creating a safer and healthier working environment for workers in the textile industry sector in Indonesia.

3. Results and Discussion

Table 1. Research Results on the Integration of Fire Prevention and Industrial Hygiene in the Textile Industry

No	Variables	Findings	Interpretation
1	OHS Awareness	65% of workers have a basic understanding of OHS, but only 40% have attended regular training.	OHS awareness is still low, so continuous training is needed to improve worker compliance.

2	Implementation of Fire Prevention System	55% of companies have automatic fire extinguishing systems, but only 30% perform regular maintenance.	The fire extinguishing system is still less than optimal due to the lack of periodic maintenance.
3	Industrial Hygiene	70% of workers experienced exposure to cotton dust, with 30% reporting respiratory symptoms.	Cotton dust exposure is still high, indicating that the ventilation system and PPE are not maximized.
4	Effectiveness of OHS Regulations	60% of companies have an OHS policy, but only 45% implement it consistently.	Regulations are in place, but implementation is still uneven across textile companies.
5	Safety Technology	40% of companies have used fire detection and air quality monitoring technologies.	The use of safety technology is still low, requiring further investment in automation systems.

Based on the results of the study, it can be concluded that the level of OSH awareness in the textile industry still needs to be improved. Although most workers have a basic understanding of OHS, the lack of regular training leads to low implementation of safety procedures in daily operations. This suggests that companies should be more active in conducting regular OHS training so that workers' awareness and compliance can increase. Furthermore, implementing fire prevention systems in the textile industry still does not yield optimal results. Although more than half of the companies have automatic fire extinguishing systems, lack of routine maintenance is the main factor that causes the system's ineffectiveness. Therefore, a strict policy is needed that requires companies to conduct regular inspections and maintenance of fire extinguishing systems.

Exposure to cotton dust is also a significant problem in terms of industrial hygiene, where around 70% of workers are still exposed to dust with the risk of respiratory problems. This indicates that the ventilation system in the workplace has not been maximized, and the use of personal protective equipment (PPE) has not been fully implemented. Therefore, improving ventilation systems and mandatory use of PPE should be a top priority to reduce health impacts for workers. Finally, the effectiveness of OSH regulations in the textile industry is still not optimal. Although most companies have OHS policies, their implementation has not been consistent. In addition, the use of safety technology is still low, with only 40% of companies using fire detection technology and air quality monitoring. Thus, there is a need for policies that encourage investment in safety technology as well as stricter supervision of the implementation of OHS regulations in the textile industry.

Table 2. List of Industrial Companies in Indonesia

No	Company Name	Location	Reason for Selection
1	PT. Sri Rejeki Isman Tbk (Sritex)	Sukoharjo, Central Java	Indonesia's largest textile company has an integrated production system.
2	PT. Pan Brothers Tbk	Tangerang, Banten	An export textile company with growing OHS management standards.
3	PT. Asia Pacific Fibers Tbk	Karawang, West Java	Has experienced fire incidents at its production facilities.
4	PT. Kahatex	Sumedang, West Java	One of the textile companies with the largest workforce in Indonesia.
5	PT. Sandang Asia Maju Abadi	Bandung, West Java	Focus on textile production with high potential fire hazards.
6	PT. Pismatex (Duniatex Group)	Surakarta, Central java	It uses modern production technology but still has industrial hygiene risks.
7	PT. Argo Pantes Tbk	Bekasi, West Java	It has an OHS management system that can be compared with other companies.
8	PT. Timatex	Malang, East Java	A medium-sized company facing OHS and industrial hygiene implementation challenges.

The companies selected in this study have different characteristics, but all have relevance to the integration study of fire prevention and industrial hygiene. PT Sritex and PT Pan Brothers were selected because they are large companies with complex production systems and high fire risk and chemical exposure. PT Asia Pacific Fibers Tbk and PT Asia Maju Abadi Sandang were selected because they have experienced fire incidents in their production facilities, so they can provide insight into the causal factors and mitigations that have been carried out. Meanwhile, PT Kahatex and PT Pismatex were selected because they have a large workforce, so industrial hygiene and occupational safety issues can be more complex than those of other companies.

In addition, PT Argo Pantes Tbk was included as a comparative study because this company has a more established OHS management system than some other companies. Finally, PT Timatex was chosen as an example of a medium-sized company that faces OHS and

industrial hygiene implementation challenges due to limited resources. By selecting companies from different scales and geographical locations, this research can provide a broader picture of the challenges and strategies for integrating fire prevention and industrial hygiene in the Indonesian textile sector.

3.1. Fire Risk Identification in Textile Industry

The textile industry has a high fire risk due to using flammable materials such as textile fibres and chemicals [3]. Research shows that fires are often caused by fibre dust accumulation and operational negligence [2]. Risk identification is the first step in fire prevention, which includes assessing contributing factors such as electrical conditions, chemical storage, and waste management [5]. Risk management theory [19] states that most industrial accidents can be prevented by identifying and eliminating the initial causes. An evaluation of fires at PT Paberik Tekstil Kasrie revealed that most incidents occurred due to electrical short circuits resulting from poorly maintained systems [15]. Therefore, regular monitoring is necessary to minimize the possibility of fire occurrence.

The application of modern technology, such as IoT-based monitoring systems, can help in the early identification of potential fires [13]. Several large textile companies in Indonesia have started implementing this technology to reduce the risk of incidents.

3.2. Implementation of Fire Prevention System

Fire prevention in the textile industry requires a systematic approach that includes technical, administrative, and worker behavioural controls [6]. One widely used approach is an automatic fire detection system that can provide early warning of fire hazards [8]. The domino theory suggests that workplace accidents can be prevented by intervening in the chain of causes before an incident occurs [18]. A fire suppression system equipped with a CO2 gas-based extinguisher has proven more effective in extinguishing fires without damaging production machinery [16].

Companies implementing this system show a 30% decrease in fire incidents in the last five years [12]. A study at PT Croda Indonesia also revealed that regular training and safety audits can improve workers' preparedness for fire [10].

3.3. Linkage of Industrial Hygiene to Occupational Safety

Industrial hygiene in textile mills is closely related to controlling fibre dust, which can potentially fuel fires [4]. Exposure to cotton dust also impacts workers' health, causing diseases such as bicinosis [11]. Work ergonomics theory emphasizes the importance of a healthy work environment to improve productivity and safety [19]. Textile companies that implement modern ventilation systems can reduce dust concentrations by 40% compared to conventional ventilation [5].

In addition, the use of appropriate personal protective equipment (PPE) is also an essential component in protecting workers from fire hazards and exposure to hazardous substances [6]. An evaluation of OHS policies in various textile factories showed that a combination of good industrial hygiene and effective fire prevention systems contributed to decreased occupational accidents [9].

3.4. Evaluation of Safety System Effectiveness

Periodic evaluation of fire safety systems is essential to ensure their effectiveness in the long term [13]. Companies regularly conducting OHS audits show higher compliance with industrial safety standards [12]. A study at PT Asia Pacific Fibers, Tbk, revealed that implementing routine inspection procedures for electrical systems can reduce the possibility of short circuits by 50% [2]. This approach aligns with quality control theory, which emphasizes the importance of continuous improvement in occupational safety management [20].

Implementing digital-based incident reporting systems is also a new trend in industrial safety evaluation. Companies that have adopted this technology show improved response to potential hazards and reduced response time in fire management [16].

3.5. Challenges and Strategies for OHS Integration Implementation

Implementing an integrated OHS system includes budget constraints, a lack of OHS experts, and resistance to changes in work culture [14]. Studies in several textile companies show that a lack of commitment from management is often a significant obstacle to the effective implementation of safety systems [8]. A phased approach to adopting safety systems, as suggested by the organizational change model [17], can help companies overcome this challenge. Implementing incentive policies for workers who comply with OHS protocols has also increased safety awareness [11].

In addition, collaboration with Occupational Safety and Health Service Companies (OSH Service Companies) can assist companies in identifying risks and designing appropriate control strategies [10]. Companies implementing this partnership-based strategy have seen a 25% reduction in fire incidents in the last three years [5].

4. Conclusion

This research confirms that integrating fire prevention strategies with industrial hygiene is crucial in improving occupational safety in Indonesia's textile industry. High fire risks, triggered by factors such as the accumulation of flammable textile fibres and poorly maintained electrical systems, can be minimized by implementing strict safety management. In addition, increased worker awareness and training on OHS standards contribute to creating a safer and more productive work environment.

Analysis of various case studies shows that companies that implement an integrated approach to fire risk management and industrial hygiene experience a reduction in occupational accidents. The main factors for this success are implementing automatic fire detection technology, sound ventilation systems, and regular air quality monitoring. In addition, government policy support and stricter regulations have accelerated the adoption of best practices in the industry.

With better policy integration and technology implementation, Indonesia's textile industry is expected to become more globally competitive. Company management should continue to update occupational safety and health strategies regarding international standards to improve worker welfare and maintain industry sustainability. Further research can be focused on measuring the effectiveness of this policy in the long term and its effect on company productivity and efficiency.

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