

Protection & Control Measures for Fire Safety in High-Risk Industrial Areas

S. Saravanakumar¹, Ather Javed²

¹Assistant professor, Dept. of Safety and Fire Engineering Excel Engineering College, Namakkal, Tamil Nadu, India.

²PG-Student, M.E-Industrial Safety Engineering, Dept. of Safety and Fire Engineering Excel Engineering College, Namakkal, Tamilnadu, India.

Emails ID: 7mechsaravanan@gmail.com¹, 7safetysaravanan@gmail.com²

Article history

Received: 19 September 2025

Accepted: 11 October 2025

Published: 25 November 2025

Keywords:

Fire Safety Protocols, High-risk industrial areas, Risk assessment, Prevention measures, Risk control, Safety measures, Fire-related risk.

Abstract

The evaluation of protection & control measures for fire safety in high-risk industrial areas is a critical aspect with far-reaching implications for the safety & safeguards of personnel and the preservation of various valuable assets in an industrial establishment. This project aims to layout an overview of the comprehensive evaluation process that consists of protection & control measures for fire safety & similar incidents. This study emphasizes the significance of regulatory compliance, employee training, and the cultivation of a strong safety culture within different industrial establishments & facilities. This project underscores the importance of critical evaluation process, which is essential for wellbeing of living beings & safeguarding of assets & property, and even for the sustainable functioning of various industrial operations across different high-risk industries.

1. Introduction

In the realm of industrial operations, safety is paramount, and in high-risk industrial areas, it becomes an even more critical concern. Among the myriad of safety concerns, fire hazards pose a significant threat to both human lives and valuable assets. Industrial fires can lead to significant environmental damage, including the release of toxic substances, air and water pollution, and the destruction of critical ecosystems. Additionally, they may pose severe health risks to nearby communities, making it crucial to assess the effectiveness of fire safety measures in minimizing these collateral impacts., property, and the environment from the devastating impacts of fire incidents. This study represents a significant step

toward achieving this critical objective. Fire safety is the set of practices intended to reduce the destruction caused by fire. A fire hazard may include a situation that increases the likelihood of a fire or may impede escape in the event a fire occurs. Fire safety is often a component of building safety. Hence, a part of our research will focus on evaluating training programs and their effectiveness in ensuring that every member of the industrial community is prepared for fire-related emergencies. In summary, this research aims to provide a holistic understanding of fire safety in high-risk industrial areas, addressing technical, operational, regulatory, and human elements. The objective is to create a robust foundation for

enhancing fire safety, reducing the potential for catastrophic incidents, and ensuring the continued prosperity of high-risk industries. This study represents a significant step toward achieving this critical objective, with the potential to save lives, protect investments, and preserve the environment while promoting economic sustainability [1].

2. Literature Review

This literature on protection & control measures for fire safety in high-risk industrial areas highlights the diverse range of health, safety, and environmental risks associated with different industrial areas. This study have identified industrial environments are inherently exposed to a diverse array of fire hazards, primarily due to the operational reliance on flammable chemicals, high-temperature processes, pressurized systems, and intricate electrical and mechanical infrastructures. Hao Zou, Yuhang Zou, Chuanyun Xiong (2025) has shown that the characteristics of high-risk buildings include high height, large area, and high-power consumption of various types of equipment. Once a high-rise building fires, it is highly likely to cause serious losses to society, including economic losses, casualties, environmental pollution, etc. According to the statistics of high-rise building fire accidents, the most frequent natural disasters occurring globally are fires, with annual economic losses caused by fires alone reaching over one billion RMB worldwide. Studies of Changcheng Liu, (2024) shows that water remains a primary extinguishing medium for industrial fires due to its availability and cooling properties. Enhancements like Chemical Additives improve flame suppression and reduce re-ignition. Physical Modifications alter droplet size and spray behavior for better coverage and penetration. Fine Water Mist Systems like fine water mist has emerged as a clean, efficient, and environmentally friendly fire suppression method. S. Nadarajah & Udayangani Kulatunga (2024) High risk fires industries represent a global challenge, inflicting economic losses, damaging reputational integrity, disrupting business operations, leading to job losses, and negatively impacting the environment. Despite strict fire regulations and codes of practice aimed at safeguarding warehouse facilities, the prevalence of catastrophic fires persists globally [2].

3. Problem Identification

Problem identification entails a meticulous examination of existing fire safety measures, risk factors, and compliance with safety standards. By identifying these problems, stakeholders can initiate targeted strategies for improvement, reinforce the resilience of these high-risk industrial environments, and ultimately reduce the likelihood of fire incidents and their devastating consequences. The evaluation of fire safety protocols and measures in high-risk industrial areas is a critical undertaking, driven by the paramount importance of safeguarding lives, assets, and the environment. The first step in this evaluation process is problem identification, which is fundamental to recognizing the challenges and vulnerabilities inherent to these complex environments. High-risk industrial areas, which encompass a wide array of sectors like chemical manufacturing, energy production, and heavy machinery operations, pose specific fire hazards due to their volatile materials, intricate processes, and potential for catastrophic incidents. By identifying these problems, stakeholders can take measures to implement various targeted strategies for improvement, reinforcing of the resilience of these high-risk industrial environments, and ultimately reducing the likelihood of any fire incidents and their associated devastating consequences [3].

4. Proposed Methodology

The first step involves the identification of all hazards which involves looking for anything that could potentially cause harm in the workplace or during an activity. By walking around the workplace, review accident/incident records, consult employees, and consider non-routine operations (maintenance, cleaning, etc.). It includes chemicals, machinery, electricity, working at heights, manual handling, slips/trips/falls. The second step involves deciding who might be affected & how? Determining who could be affected by each hazard and in what way. The third step involves evaluating the risks and deciding on suitable precautions. This can be achieved by assessing the likelihood and severity of harm from each hazard, and decide what control measures are needed. The fourth step involves recording the findings and implementing them by documenting the details like associated hazards, who might be harmed, the risks, and the

precautions taken. Assigning responsibilities and deadlines for implementing controls. Ensuring intact recording in the form of written report, action plan, updated safety procedures. The fifth step involves reviewing the assessment and updating as per the necessity by regularly revisiting the risk assessment to ensure it remains valid and effective and reviewing near misses, changes in processes, introduction of new equipment, or periodically (e.g., annually) Shown in Figure 1.

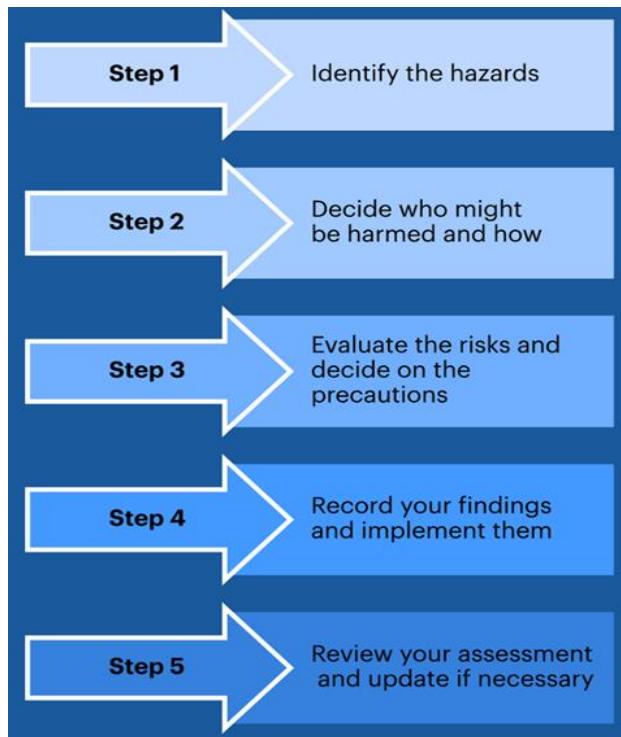


Figure 1 Methodology

5. Protection & Control Measures

5.1. Types of Fire Safety Protocols in Industries

Fire safety protocols in industrial settings are crucial for preventing, mitigating, and responding to fire incidents. These protocols encompass a wide range of measures and practices. Here are some common types of fire safety protocols in industries: Implementing designated smoking areas and enforcing strict no-smoking policies in industrial zones. Requiring permits for any work involving open flames or sparks. Installing smoke detectors to identify the presence of smoke or fire. Using heat detectors to sense temperature changes indicative of a fire. Employing flame detectors to identify the presence of flames. Automatic water-

based systems that activate when a fire is detected. Conducting regular evacuation drills to ensure employees are familiar with procedures. Providing training to employees on fire safety, including how to use fire extinguishers, evacuate safely, and report fire hazards. Employing fire modeling and predictive analytics to enhance fire prevention and response. Adhering to local, national, and international safety standards and regulations applicable to the specific industry. Implementing measures to reduce environmental impacts in case of a fire, such as containment systems and pollution control measures [4].

5.2. Fire safety Protocols in Construction Industry

Fire safety protocols in the construction industry are vital to prevent fires, protect workers, and ensure the safety of the construction site. Site Inspection: Conduct a thorough assessment of the construction site to identify potential fire hazards. Access and Egress Routes: Plan clear and unobstructed routes for emergency access and evacuation. Store flammable materials in designated, fire-resistant areas away from ignition sources. Smoking Policies: Enforce no-smoking policies in and around construction areas. Hot Work Permits: Require permits for any welding, cutting, or other hot work activities. Install detectors that trigger alarms in case of smoke or elevated temperatures. Ensure the site is equipped with fire alarm systems to alert workers in case of a fire Shown in Figure 2.

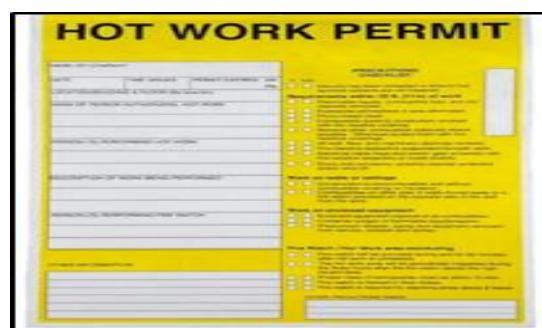


Figure 2 Hot work permit

Place portable fire extinguishers strategically across the construction site. Provide accessible fire hose reels to tackle small fires. Ensure a reliable water supply is available for fire suppression. Regularly inspect and maintain equipment to prevent electrical and mechanical

Protection & Control Measures for Fire Safety
failures. Safely store and handle fuels used for construction equipment Shown in Figure 3.



Figure 3 Fire Suppression Systems

Ensure all electrical wiring is correctly installed and protected from damage. Store flammable materials in approved containers and areas. Have spill control measures in place to contain hazardous material leaks. Develop and regularly practice evacuation plans specific to the construction site. Ensure all workers are aware of the assembly points for evacuations. Establish communication systems for workers to report fires and other emergencies. Maintain a clean and organized construction site to reduce the risk of fire spread and improve access for emergency responders. Implement measures to prevent environmental damage in case of a fire, such as spill containment systems and erosion control measures Shown in Figure 4.



Figure 4 Fire safety protocols in Construction Industry

Fire safety in the construction industry is a shared responsibility that requires vigilance, planning, and strict adherence to protocols to protect both workers and the construction site Shown in Figure 5. Regular training, communication, and oversight are essential to maintaining a safe construction environment Shown in Table 1.

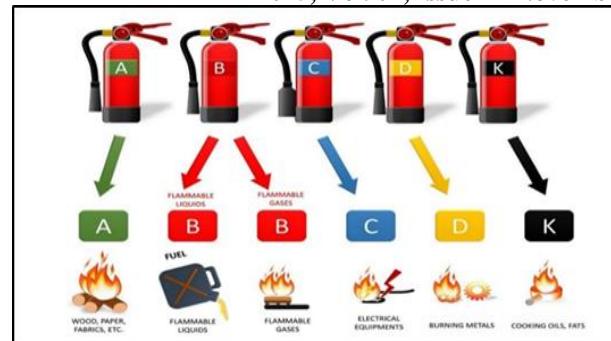


Figure 5 Fire extinguisher types and uses

Wall types	Thermal conductivity k (W/m K)	Density ρ (kg/m ³)	Specific heat c (kJ/kg K)	Heat capacity ρc (kJ/m ³ K)	Thermal diffusivity α (m ² /s)
Briquette	0.920	1600	0.840	1344.00	6.84×10^{-7}
Brick	0.690	1580	0.840	1327.20	5.20×10^{-7}
Blockbims	0.230	770	0.835	642.95	3.57×10^{-7}
AAC	0.150	400	1.047	418.80	3.58×10^{-7}
Concrete	1.370	2076	0.880	1826.88	7.50×10^{-7}
Plaster	0.700	2778	0.840	2333.52	2.99×10^{-7}
XPS	0.034	22	1.280	281.60	12.1×10^{-7}
EPS	0.038	18	1.500	27.00	14.0×10^{-7}
Siding	0.094	640	1.170	748.80	1.26×10^{-7}

Table 1 Thermo physical properties of building materials

5.3. Fire safety Protocols in Chemical Industry

Fire safety protocols in the chemical industry are of paramount importance due to the potentially volatile and hazardous nature of chemicals used and stored in these facilities. These protocols aim to prevent fires, mitigate risks, and protect personnel and the environment. Clearly label and classify hazardous chemicals according to local and international standards (e.g., GHS). Maintain SDS for all chemicals on-site, providing essential information on hazards, safe handling, and emergency response. Store chemicals in compatible groups to prevent reactions in case of spills or leaks Shown in Figure 6.



Figure 6 Chemical Accidents in the Workplace

Strictly enforce no-smoking policies throughout the facility. Hot Work Permits: Require permits for any welding, cutting, or other hot work activities. Implement measures to prevent static electricity discharge, which can ignite flammable chemical. Implement bonding and grounding of equipment to prevent static electricity buildup Shown in Figure 7.

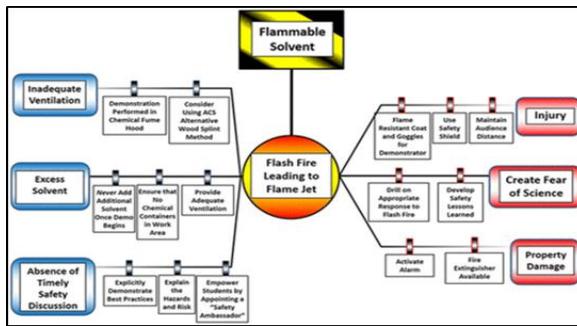


Figure 7 Fire safety protocols in Chemical Industry

Regularly audit and inspect the facility to identify and rectify potential fire hazards. Maintain documentation of inspections and any corrective actions taken. Establish access control and security measures to prevent unauthorized entry and potential sabotage. In the chemical industry, fire safety is an ongoing and collaborative effort that involves stringent regulatory compliance, training, technology, and thorough emergency response planning. Ensuring that all employees are well-informed, well-prepared, and that equipment and systems are properly maintained is essential to preventing fires and managing chemical hazards effectively Shown in Table 2.

autoignition temperatures		
common fuels	deg C	deg F
diesel	210	410
fuel oil	210-262	410-504
gasoline	246-280	476-536
kerosene	295	563
butane	405	761
propane	470	878
natural gas	580	1076
other things	deg C	deg F
paper	220-250	428-482
wood	300-500	572-932
ethanol	363	685
rubbing alcohol	400	752
methanol	470	878
carbon monoxide	609	1128

Table 2 Ignition temperature of ten substances

5.4. Fire safety Protocols in Oil & Gas Industry

Fire safety protocols in the oil and gas industry are of critical importance due to the high risks associated with the extraction, processing, and transportation of flammable hydrocarbons. These protocols are designed to prevent fires, manage risks, and protect workers, assets, and the environment Shown in Figure 8 and 9.

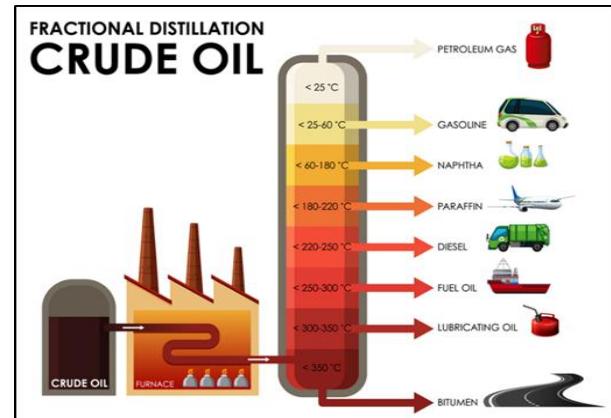


Figure 8 Heating Oil Distillation Process in Oil & Gas Industry

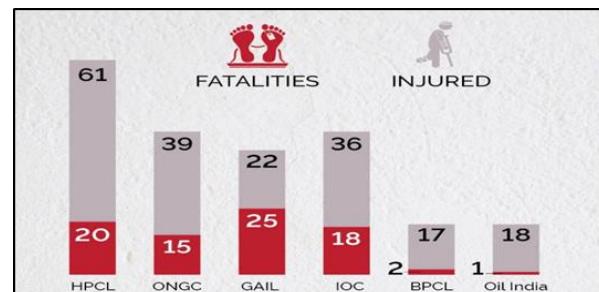


Figure 9 Graph 3 Fire safety accidents in oil industry

Implement isolation and lockout/tagout procedures during maintenance. Use intrinsically safe electrical equipment in hazardous areas. Employ electrical classification and ensure that equipment is suitable for the location. Require hot work permits for any welding, cutting, or other hot work activities. Conduct gas tests to ensure a safe environment before commencing hot work. Install advanced fire detection and alarm systems that are capable of identifying hydrocarbon fires. Utilize gas detection systems to monitor for the presence of flammable or toxic gases. Implement automatic fire suppression systems, including foam and chemical extinguishing agents, where applicable Shown in Figure 10.

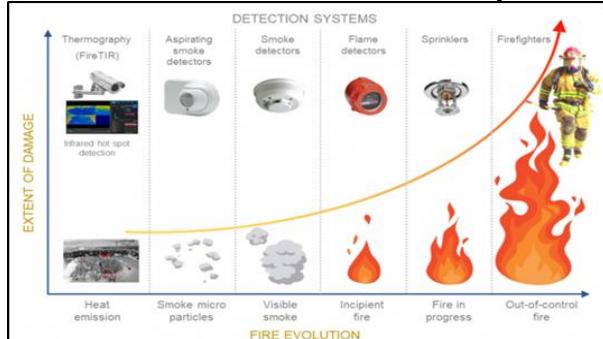


Figure 10 Stages of Fire: Detection and Warning Systems

Control ignition sources such as open flames, spark-producing equipment, and electrical equipment in hazardous areas. Develop and implement spill response plans to prevent hydrocarbon spills from contaminating the environment. Use containment measures to prevent spills from spreading. Implement well control measures, such as blowout preventers, to manage potential blowouts and uncontrolled releases of hydrocarbons Shown in Figure 11.



Figure 11 Fire safety protocols in Oil & Gas Industry

Regularly conduct fire safety audits and inspections of facilities to identify and address potential fire hazards. In the oil and gas industry, fire safety is a comprehensive and continuous effort that involves stringent regulatory compliance, robust training, advanced technology, and meticulous planning. Ensuring the safety of personnel, assets, and the environment is paramount in a sector where the potential consequences of fire incidents can be catastrophic [5 - 7].

5.5. Fire safety Protocols in Textile Industry

Fire safety protocols in the textile industry are essential to protect workers, machinery, and facilities from the potential fire hazards associated with textile production processes. These protocols aim to prevent fires, ensure a rapid response in case

of an emergency, and minimize the impact of fire incidents. Secure the facility after hours to reduce the risk of fire incidents caused by trespassers. Fire safety in the textile industry is a collaborative effort that requires diligence, training, adherence to regulations, and the application of best practices to protect workers and facilities from the risks associated with textile production processes. The goal is to create a safe working environment and minimize the potential for fire incidents Shown in Figure 12.



Figure 12 Fire safety protocols in Textile Industry

5.6. Fires safety Protocols in Woodworking Industry

Fire safety protocols in the woodworking industry are essential to minimize the risk of fires and protect workers, machinery, and facilities from potential hazards. Woodworking processes involve various flammable materials and tools, making fire safety crucial. Here are key fire safety protocols specific to the woodworking industry Shown in Figure 13:



Figure 13 Fire safety protocols in woodworking industry

Ensure that electrical systems and equipment are in good working condition and comply with safety standards. Use appropriate wiring methods, electrical enclosures, and equipment in areas where flammable materials are present. Regularly inspect and maintain woodworking machinery to

prevent mechanical failures that can lead to fires. Develop maintenance procedures and schedules to ensure safe machine operation. Install fire detection and alarm systems to detect and alert personnel to the presence of smoke, flames, or elevated temperatures. Develop and practice emergency response plans that include procedures for evacuating employees and responding to fires. Fire safety in the woodworking industry is crucial for the protection of personnel, equipment, and property. Strict adherence to safety protocols, training, and preventive measures can help minimize the risk of fires in woodworking operations and create a safer work environment.

5.7. Fire safety Protocols in Electronics Industry

Fire safety protocols in the electronics industry are essential to prevent fires and protect workers, equipment, and facilities from potential hazards associated with electronic manufacturing and assembly processes. The electronics industry often involves sensitive components, electrical systems, and flammable materials, making fire safety a top priority. Ensure that electrical systems, equipment, and wiring are in compliance with safety standards and regularly inspected and maintained. Implement proper grounding and bonding to prevent static electricity discharge. Regularly inspect and maintain manufacturing equipment and machinery to prevent mechanical failures that can lead to fires. Develop maintenance procedures and schedules to ensure safe machine operation Shown in Figure 14.



Figure 14 Fire safety protocols in Electrical Industry

Provide fire safety training to all employees, covering fire prevention, evacuation procedures, and the use of fire safety equipment. Conduct regular fire drills to assess preparedness and response effectiveness. Supply employees with

appropriate PPE, such as fire-resistant clothing, safety glasses, and respiratory protection, as needed. Comply with local, national, and international safety regulations and industry standards applicable to electronics manufacturing processes. Regularly audit and inspect the electronics manufacturing facility to identify and address potential fire hazards. Maintain records of inspections and corrective actions [8-10]. Implement effective dust control measures, especially in environments with dust-producing equipment. Control static electricity through proper grounding, bonding, and the use of antistatic materials. Establish effective communication systems for reporting fires and other emergencies. Maintain a list of emergency contact numbers. Implement security measures to prevent unauthorized access, vandalism, and arson. Secure the facility after hours to reduce the risk of fire incidents caused by trespassers Shown in Figure 15.



Figure 15 Dust Control and Static Electricity in electronics industry

Stringent adherence to safety protocols, comprehensive training, and preventive measures can help minimize the risk of fires in electronic manufacturing and assembly processes, ensuring a safer working environment.

6. Fire Safety Protocols Identification

6.1. Fire Safety Protocols Identification in Industries

Identifying and implementing fire safety protocols in various industries is essential to prevent fires, protect personnel, and safeguard assets. Identify potential fire hazards in the workplace. This includes materials, equipment, processes, and environmental factors that could contribute to a fire. Consider the consequences of fires, including damage, injuries, and environmental impact. Analyze the specific industrial processes,

Protection & Control Measures for Fire Safety

machinery, and operations to identify any areas where fire hazards are most likely to occur. Identify the types of materials present in the workplace that are flammable, combustible, or otherwise pose a fire risk. Evaluate the existing emergency response plans to ensure they are comprehensive and address various fire scenarios. Ensure that personnel are informed about fire safety procedures and equipment use. Implement control measures to mitigate fire hazards. It requires a proactive approach, regular review, and continuous improvement to adapt to changes in processes, technology, and regulations. Fire safety is a shared responsibility that involves all levels of an organization, from management to front-line employees, and requires vigilance and commitment to ensuring a safe working environment [11].

6.2. Outcomes for Fire Safety Protocol Identification

The identification of fire safety protocols in an industrial setting can lead to several important outcomes that are crucial for the safety of personnel, protection of assets, and the overall functioning of the organization. Identifying fire safety protocols helps in recognizing and mitigating potential fire hazards, reducing the risk of fire incidents and their associated consequences. Shown in Figure 16.



Figure 16 Graph 4 Outcomes for Fire

Proper identification and implementation of fire safety protocols ensure compliance with local, national, and international fire safety regulations and standards, preventing legal issues and fines. Identifying and implementing fire safety protocols reduces the risk of fires spreading and causing environmental damage, which can result in costly cleanup and potential legal liabilities [12]. The identification and implementation of fire safety

2025, Vol. 07, Issue 11 November

protocols can protect the organization from legal liabilities in the event of fire-related injuries, deaths, or property damage. Identifying fire safety protocols helps allocate resources more efficiently by focusing on areas where fire risk is the highest. Shown in Figure 17.

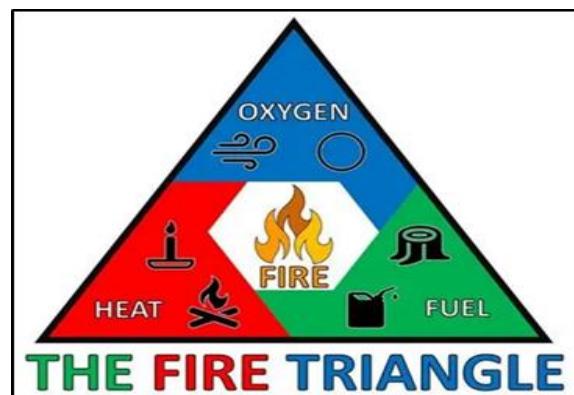


Figure 17 Outcomes for Fire Safety Protocol Identification

Knowing that comprehensive fire safety protocols are in place provides peace of mind to employees, management, and stakeholders. The outcomes of fire safety protocol identification contribute to a safer and more secure work environment, which ultimately benefits both the organization and its employees [13].

7. Quality Risk Management

7.1. Principles of Fire Safety Protocol quality Risk Management

Quality risk management in fire safety protocols involves the systematic identification, assessment, and control of risks to ensure that the protocols are effective and reliable. Regularly test and validate the effectiveness of fire safety protocols through drills, simulations, and real-life scenarios. These principles ensure that the protocols are not only compliant with regulations but also effective in minimizing fire-related risks and their potential consequences [14].

7.2. Risk Assessment

Risk assessment is a crucial component of fire safety protocols in any setting, including industrial, commercial, and residential environments. It involves systematically identifying and evaluating potential fire-related risks to determine their severity and likelihood of occurrence. The objective is to prioritize and address these risks to reduce the potential for fire incidents. Shown in Figure 18.



Figure 18 Risk Assessment Matrix

Begin by identifying potential fire hazards within the area or facility. This includes materials, equipment, processes, and environmental factors that could contribute to a fire. Once hazards are identified, assess how likely it is that these hazards could lead to a fire incident. Consider factors such as the presence of ignition sources, the type of materials involved, and the conditions under which they are stored or used. Prioritize the identified risks based on their level of risk. Focus on the most significant risks, which pose the greatest threats to safety and property. These strategies may include control measures, safety protocols, and preventative actions to reduce the likelihood of fire incidents and their consequences. Regularly review and update the risk assessment as conditions change, new hazards are identified, or new information becomes available. Ensure that employees are informed about the risks identified, the measures in place to mitigate them, and their role in fire prevention and response. Regularly test and validate the effectiveness of the risk mitigation strategies through drills, simulations, and real-life scenarios. It helps organizations prioritize their safety efforts and allocate resources where they are needed most to reduce the risk of fire incidents and their consequences [15].

7.3. Risk Control

Risk control in fire safety protocols involves implementing measures and strategies to minimize or eliminate the identified fire-related risks. The goal is to reduce the likelihood of fire incidents and limit their potential consequences. Implement preventive actions to reduce the likelihood of fire hazards. This may include measures such as good housekeeping, proper storage of flammable materials, and regular maintenance of equipment. Shown in Figure 19 Heriarchy of risk control.

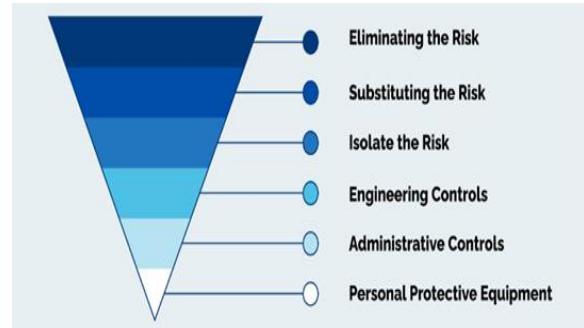


Figure 19 Heriarchy of risk control

- **Engineering Controls:** Utilize engineering controls to manage fire risks. Examples include firereseistant building materials, ventilation systems, and electrical enclosures designed to prevent the spread of fires [16].
- **Substitution:** Substitute flammable materials with less hazardous alternatives when possible. This reduces the fire risk associated with certain materials.
- **Isolation:** Isolate potential fire hazards from other parts of the facility or workplace. Use barriers or fire-rated walls to contain the risk Shown in Figure 20.

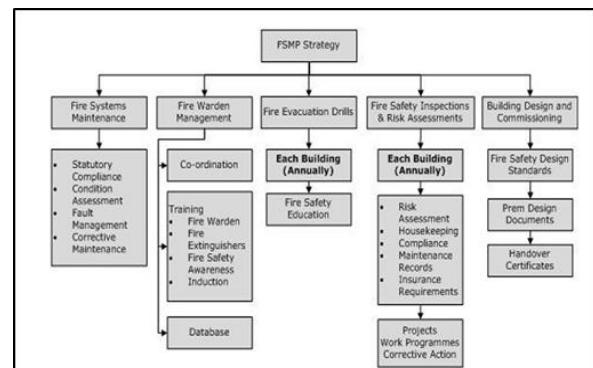


Figure 20 Risk Control for Fire Safety Protocol Identification

- **Administrative Controls:** Implement administrative controls, such as written safety procedures and policies, to guide employee behavior and reduce the risk of fire incidents.
- **Training and Education:** Provide fire safety training to all employees, making sure they understand the risks and how to respond in case of fire. Education promotes safety awareness and responsible behavior.

- **Safety Protocols:** Develop and implement specific safety protocols for handling hazardous materials, hot work, or other high-risk activities. This ensures that the risks associated with these activities are well-managed [17].

8. Results - Role of Fire Safety Protocols Controls

Fire safety protocols consist of a series of controls and measures designed to prevent, detect, and respond to fire incidents. These controls are essential for ensuring the safety of personnel and the protection of property and assets.

Regularly clean and maintain the workplace to eliminate flammable debris and reduce the risk of fires. Store flammable materials in designated areas with proper ventilation and separation from ignition sources. Implement a permitting system for hot work activities like welding and cutting to ensure safety precautions are followed. Enforce strict no-smoking policies and designate designated smoking areas. Isolate and safeguard potential ignition sources such as electrical equipment and machinery [18]. Implement grounding and bonding procedures to prevent static electricity discharges Shown in Figure 21.



Figure 21 Outcomes for Fire Safety Protocol Identification

Use of fire-resistant construction materials to slow the spread of fires. Install ventilation systems to control the movement of smoke and gases in the event of a fire. Use fire-rated enclosures to contain electrical faults and prevent the spread of fires. Develop and enforce written safety policies and procedures related to fire safety. Use heat detectors to detect elevated temperatures, especially in areas where smoke detectors may not be suitable. Flame-Resistant Clothing: Provide employees with flame-resistant clothing to protect them in the event of a

fire. Safety Glasses and Respiratory Protection: Equip employees with safety glasses and respiratory protection as needed.

Conclusion

In conclusion, the evaluation of fire safety protocols and measures in high-risk industrial areas is of paramount importance for safeguarding lives, protecting property, and ensuring the continued operation of industrial facilities. The multifaceted approach to fire safety, encompassing risk assessment, prevention, detection, response, and continuous improvement, is essential for mitigating the devastating consequences of fire incidents. Through regulatory compliance, training, and a strong safety culture, organizations can significantly reduce the likelihood of fires and limit their impact when they do occur. The valuable lessons learned from research, case studies, and international perspectives contribute to the development of more effective fire safety protocols. As technology and regulations evolve, it is crucial for industries to adapt, enhancing their readiness to face the ever-present threat of fire. The proactive identification and control of fire-related risks, along with a commitment to quality risk management, ensure that the safety of personnel remains at the forefront of industrial operations, paving the way for a safer and more resilient future in high-risk industrial settings.

Reference

- [1]. From Inception to Innovation: A Comprehensive Review and Bibliometric Analysis of IoT-Enabled Fire Safety Systems AlQahtani et al. <https://www.mdpi.com/2313-576X/11/2/41>
- [2]. Hao Zou, Yuhang Zou, Chuanyun Xiong J. (2023) "Fire Safety Management in High-Risk Industrial Facilities." Environmental Science Research Center Vol. 5 No.3, pp. 181-188
- [3]. Brief Introduction on Advances in Fire Suppression Liu et al. <https://www.mdpi.com/2571-6255/7/9/309>
- [4]. Nadarajah, S., Kulatunga, U., Weerasooriya, D. and Rathnasinghe, A.P., 2024. Fire under control: Enhancing warehouse safety through strategic fire prevention and risk management. In: Sandanayake, Y.G., Waidyasekara, K.G.A.S., Ranadewa, K.A.T.O. and Chandanie, H. (eds). Proceedings of the 12th World Construction

Symposium, 9-10 August 2024, Sri Lanka. pp. 518-531. DOI: <https://doi.org/10.31705/WCS.2024.41>. Available from: <https://ciobwcs.com/papers/>

[5]. https://www.globalscientificjournal.com/researchpaper/factors_influencing_the_implementation_of_fire_safeguards_a_qualitative_approach_a_case_study_at_the_job_marketing_center_office_head_office_ministry_of_manpower_.pdf

[6]. Fire Technology, 61, 1–2, 2025 The Author(s), under exclusive licence to Springer Science+Business Media, LLC, part of Springer Nature Manufactured in The United States <https://doi.org/10.1007/s10694-024-01697>

[7]. Innovations in Fire Detection and Suppression Systems for Oil Refinery Operations Ekunke et al.<https://pathofscience.org/index.php/ps/article/view/3377/1604>

[8]. A Deep-Learning-Based Approach to the Classification of Fire Types Refaee et al. <https://www.mdpi.com/2076-3417/14/17/7862>

[9]. https://www.researchgate.net/publication/388825476_theoretical_and_methodological_foundations_of_fire_risk_management_in_residential_buildings

[10]. Zhang, C. Review of Structural Fire Hazards, Challenges, and Prevention Strategies. Fire 2023, 6, 137. <https://doi.org/10.3390/fire6040137>

[11]. Uuganbayar Enkhtaivan, Urjin Odkhuu, Sarantsetseg Bazarvaani. (2025) The Fire Risk Analysis of Mongolia. International Journal of Innovative Technologies in Social Science. 1(45). [http://doi:10.31435/ijitss.1\(45\).2025.3127](http://doi:10.31435/ijitss.1(45).2025.3127)

[12]. https://www.researchgate.net/publication/385871601_A_Review_on_Structural_Fire_Safety_in_Urban_Area_Buildings_in_Prescriptive_Codes_of_Developing_Countries

[13]. Liu Dongbo. Constraints and improvement measures for fire extinguishing in high-rise buildings [J] Fire Science and Technology, 2017,36 (8): 1129-1131.

[14]. Shen Youdi. Research on Fire Safety Technology for High rise Buildings [J] Fire Science and Technology, 2009,28 (2): 130-133

[15]. Wang Su. High rise building fire risk assessment based on grey correlation analysis [J] China Safety Production Science and Technology, 2013,9 (8): 83-89.

[16]. Yang Siling, Jiang Genmou. High rise building fire risk assessment based on IAHP and Vague set [J] Journal of East China Jiao Tong University, 2017,34 (1): 124-131.

[17]. Duan Meidong, Jiang Dongmin, Ding Ling, et al FANP-BP High rise Building Fire Risk Assessment Model and Its Application [J]. Fire Science and Technology, 2015,34 (11): 1530-1533.

[18]. Liu Yunfen Second level variable fuzzy evaluation of fire risk in high-rise buildings [J] China Safety Production Science and Technology, 2012,8 (3): 165-169.