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# EVALUATION OF FIRE RISK ASSESSMENT IN TRANSIT RAIL MANUFACTURING INDUSTRY

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**ABSTRACT**

Fire is a substantial danger that can arise from either natural or human- caused factors. Fires can typically be categorized into five groups based on the type of fuel being burned. Damages caused by fires can be categorized as harm to the physical structure, loss of human lives, and damage to properties. Studying the fire loads in various compartments and ensuring adequate firefighting equipment can aid in mitigating the intensity of fires. The fire loads and fire densities were examined to find the necessary firefighting equipment. Fire risk assessment is the act of finding potential dangers in various locations as well as individuals who may be in jeopardy. It involves analyzing and diminishing risk by engaging in discussions with employees and implementing necessary measures to rectify any issues. This project focuses on evaluating the potential risks of fire, calculating the fire load in the various small factory unit, and determining the location of the XYZ transit rail manufacturing industry. The aim is to reduce the combustible material and implement a fire separation system to reduce the fire risk according to the following standards: IS2190, IS15683, NFPA 577.

**KEYWORDS:** Fire load, Fire Risk Assessment, Firefighting Equipment's, IS 2190, IS 15683, NFPA 577.

## 1. INTRODUCTION

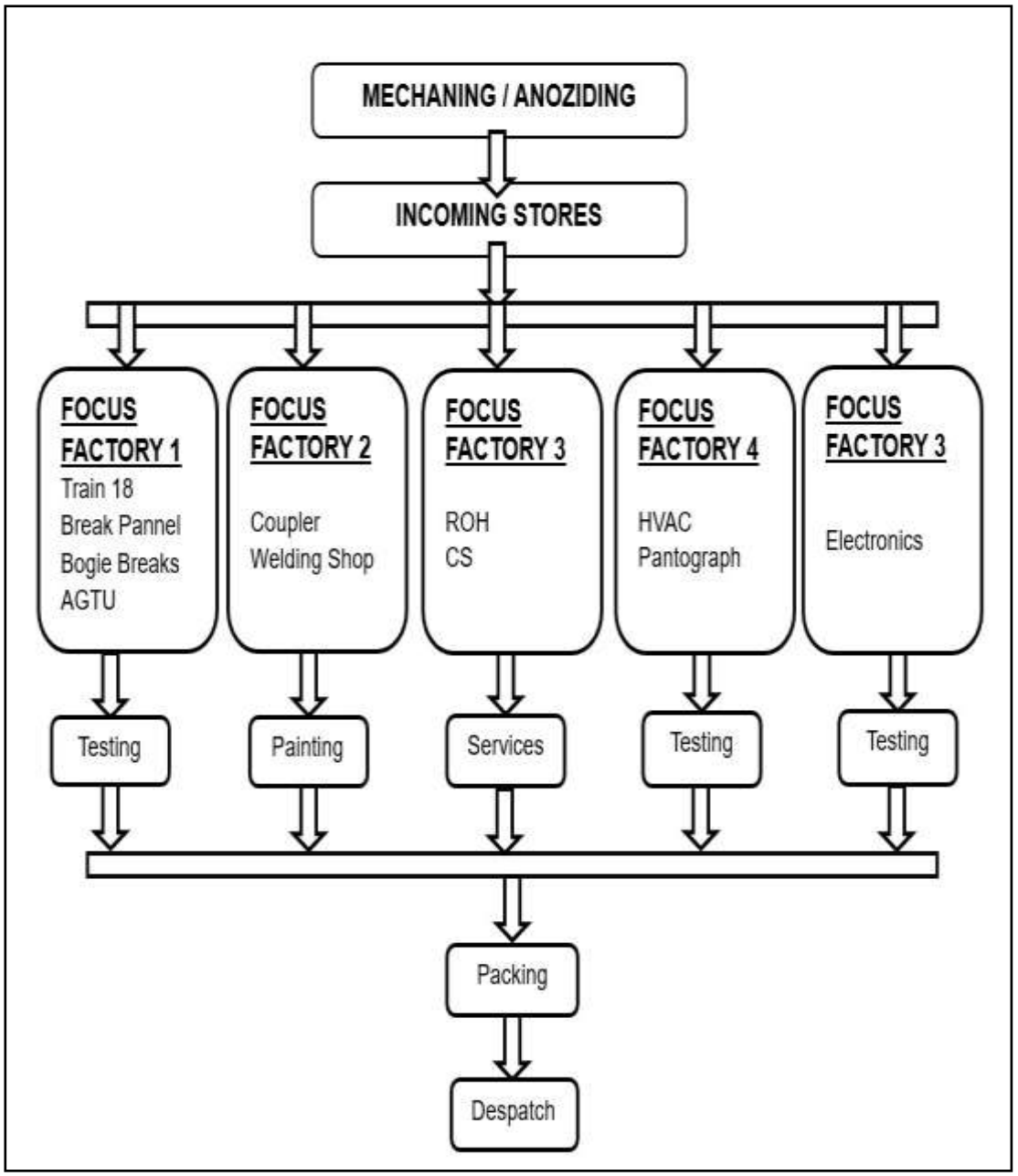
In the dynamic landscape of industrial safety, the threat of fire remains a pervasive and potentially catastrophic risk. Whether ignited by natural elements or human activities, fires pose a significant danger to both life and property. Understanding the nuances of fire risks is crucial for industries, particularly those involved in transit rail manufacturing, where the stakes are high due to the intricate interplay of diverse materials and processes. This research delves into the critical realm of fire risk assessment within the XYZ transit rail manufacturing industry. Fires, as complex phenomena, necessitate a meticulous examination of the factors contributing to their occurrence. The categorization of fires based on fuel types provides a foundational understanding, enabling a more nuanced evaluation of potential hazards. The repercussions of fires extend beyond immediate damage to physical properties; they encompass the loss of human lives and damage to valuable properties. Recognizing this, the study goes beyond the surface by scrutinizing fire loads in various compartments, seeking a comprehensive understanding of the potential risks. By evaluating fire densities, the research aims to pinpoint the exact requirements for firefighting equipment, ensuring preparedness to mitigate the intensity of fires effectively. Fire risk assessment, a pivotal facet of industrial safety, involves not only identifying potential dangers but also engaging in proactive measures to reduce risk. This project adopts a holistic approach, intertwining the analysis of fire risks with a proactive strategy that involves discussions with employees and the implementation of necessary corrective measures. The goal is to create a safer environment for both the workforce and the infrastructure. Aligned with safety standards such as IS 2190, IS 15683, NFPA 557, NFPA 10, Factories Act 1948 and Tamil Nadu Factories Rules 1950, this project aspires to set a benchmark for fire risk reduction in the transit rail manufacturing industry.

Through meticulous evaluation and strategic implementation of fire suppression systems, the aim is to shorten combustible materials and, consequently, reduce the overall fire risk. This endeavor stands as a testament to the commitment of the XYZ transit rail manufacturing industry to ensuring the highest standards of safety and resilience in the face of potential fire threats.

### 1.1 OVERVIEW OF COMPANY

XYZ transit rail manufacturing industry, a global leader in transportation solutions, is a Fortune 500 company that has significantly impacted the world's transportation landscape. XYZ transit rail manufacturing industry manufactures locomotives, freight cars, and related equipment for the global freight rail industry, known for their power, efficiency, and reliability. They also provide a wide range of solutions for passenger rail transportation, including electric and hybrid locomotives, as well as accessible and modern passenger cars. XYZ transit rail manufacturing industry also offers a suite of digital solutions and value-added services, such as Positive Train Control (PTC), Asset Management, and Data Analytics. A safety system that prevents train collisions and derailments, Asset Management optimizes the maintenance and performance of locomotives and other equipment, and Data Analytics provides insights into operational efficiency and safety. XYZ transit rail manufacturing industry's focus on sustainability and passenger comfort is evident in their development of electric and hybrid locomotives and modern passenger cars.

### 1.2 PRODUCTION PROCESSES OF COMPANY



## 2. LITRATURE REVIEW

**DETERMINATION OF FIRE LOAD AND HEAT RELEASE RATE FOR HIGH-RISE RESIDENTIAL BUILDINGS., J. LIU, W. K. CHOW -** This article focuses on design fires and fire load survey methods for buildings. It explores the characteristics of heat release rate in the fire growth stage and post- flashover stage and presents issues that should be considered for high-rise residential buildings. The advantages and limitations of different fire load survey methodologies are summarized, and a fire load survey method suitable for residential buildings and the data needed to be collected are recommended.

**ESTIMATION OF FIRE LOAD AND ITS RISK ASSESSMENT IN WAREHOUSE., N. ARUNRAJ, C. SENTHIL KUMAR, K. VIJAY MARUTHI -** This paper addresses an important issue of fire hazard in the automobile industry, specifically focusing on the analysis of fire loads and fire densities in the Warehouse of Ashok Leyland. The study employs various methodologies to calculate fire loads, and the results are discussed in detail. The paper provides valuable insights into the potential risks associated with fire, and it suggests measures to reduce fire load in the industry. However, there are several areas that need improvement and clarification.

**FIRE LOAD AND FIRE GROWTH CHARACTERISTICS IN MODERN HIGH-RISE BUILDINGS., UGUR DUNDAR, SERDAR SELAMET -** This paper provides valuable insights into fire load and fire growth characteristics in modern high-rise buildings, specifically focusing on residential apartments in Istanbul, Turkey. The study addresses a critical aspect of fire safety design and presents survey results from 50 high-rise buildings. While the paper offers important contributions, there are some areas that require clarification and improvement.

**FIRE LOAD CALCULATION ON HOSPITAL BUILDINGS IN INDIA, MANISH NIGAM, AWADHESH KUMAR SINGH, ABHISHEK DIXIT** - This paper provides valuable insights into calculating Fire Load on Hospital Buildings in India; discussing the parameters that should be considered when calculating the fire load; discussing the importance of ventilation and heat loss to boundaries; providing guidance on data collection survey methods; and suggesting further research into the impact of factors such as time, regional and cultural differences, and scenario on fire load. Fire load calculation on Hospital Buildings in India; not providing detailed information on the methodology used to conduct the survey; not providing detailed information on the potential risks associated with Fire Load Calculation on Hospital Buildings in India; and not providing detailed information on how to mitigate potential risks.

**FIRE LOAD DENSITY AND FIRE ADEQUACY – AN IMPORTANT TOOL FOR FIREFIGHTING, KIRAN PAWAR, GAURI RANE -** This paper has several strengths. Firstly, it provides an overview of the International Journal for Innovative Research in Multidisciplinary Field, including its origin and focus. Secondly, it outlines the methods used to conduct research, such as direct measurement of mass and volume, energy release measurement by calorimetry of an item, and calculation of fire load and fire load density. Thirdly, it explains how fire adequacy is assessed and the standard water requirement for the journal. Finally, it provides useful conclusions and suggests methods to reduce the fire load and increase fire safety. The paper does not provide any concrete recommendations on how to reduce the fire load and increase fire safety. Additionally, it does not discuss the potential consequences of not meeting the fire safety requirements outlined in the Gujarat Factories Rules 1963. Finally, it does not provide any information on the methods used to measure the calorific value of combustible materials.

## 3. PROBLEM IDENTIFICATION

### 3.1 RISK AND HAZARD IN TRANSIT RAIL MANUFACTURING INDUSTRY

The transit rail manufacturing industry is a significant contributor to the production of rail vehicles, including trains and subways. This industry faces numerous risks and hazards, including fire safety. These include improper storage and handling of materials, ignition sources, high-voltage electrical systems, overheating components, malfunctioning machinery and equipment, welding and hot work operations, combustible dust, fire suppression systems, emergency response plans, and regulatory compliance. Material storage and handling are crucial for preventing fire hazards in the transit rail manufacturing sector. Improper storage or mishandling of materials can lead to fire hazards. Ignition sources, such as sparks generated during

welding and cutting, can ignite nearby flammable materials if not handled properly. High-voltage electrical systems, such as those used in transit rail vehicles, can be prone to fires due to faulty wiring, electrical shorts, or equipment malfunctions. Overheating components, such as traction motors and control systems, can also pose a fire risk. Machinery and equipment malfunctions, such as bearings or hydraulic systems, can lead to fire incidents. Proper storage, handling, and disposal procedures are essential. Lubricants and fuel leakage can contribute to fire hazards. Welding and cutting processes can generate combustible dust, which can increase the risk of fire. Regular cleaning and ventilation measures are necessary. Fire suppression systems, such as sprinklers, Fire Monitors and fire extinguishers, should be in place throughout the manufacturing facility. Emergency response plans, including evacuation procedures and communication protocols, are essential, and employee training on emergency procedures can minimize the impact of a fire incident. Regular audits and inspections, Fire Drill and Mock drills were conducted by regulatory authorities are crucial for ensuring the manufacturing facility meets safety standards. In conclusion, a comprehensive and proactive approach to safety is essential in the transit rail manufacturing industry.

### 3.2 TYPES OF HAZARDS

In a transit rail manufacturing unit, all the hazards mentioned in this session may not be common, but awareness about various hazards is essential to be able to deal with them in case they occur. Different work environments can pose different type of hazards and risks to the health of the Operators. Therefore, it is important to identify and address the different types of hazards with appropriate safety measures, not only by the employers but also for everyone to be responsible for the safety and hygiene of the self. There is always a threat to the health and safety of people at the workplace. These may be chemical hazards, physical hazards, biological hazards, etc. Here we have discussed some hazards keeping in mind the exposure of students of this course towards machines and industry.

Physical Hazard
Fire Hazard
Chemical Hazard
Psychosocial Hazard
Electrical Hazard
Ergonomic Hazard

### 3.3 HEALTH AND SAFETY MEASURES FOR RAIL AND TRANSIT MANUFACTURING INDUSTRY

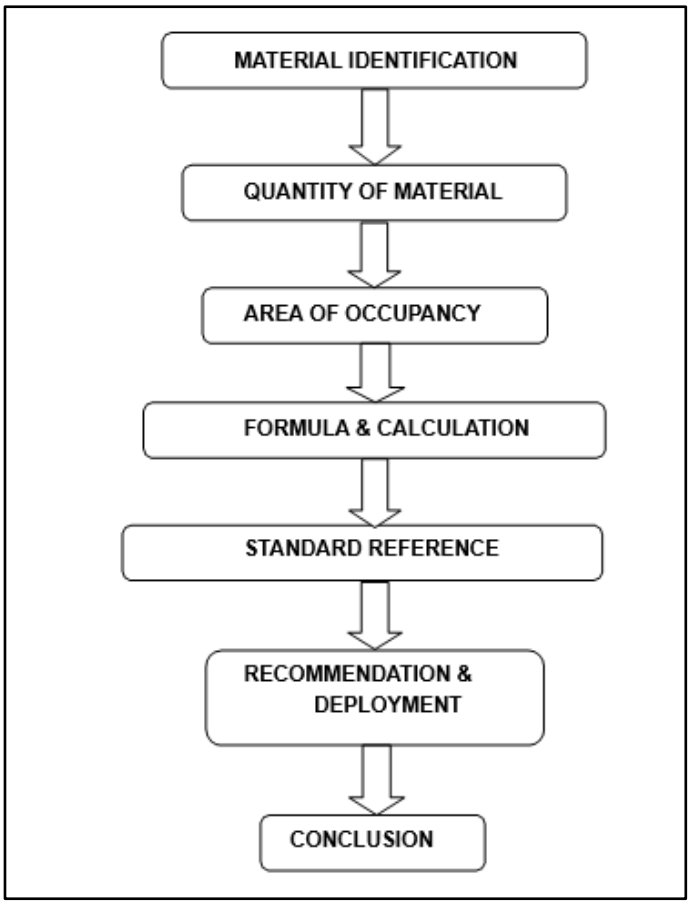
Ensuring the health and safety of employees in the rail and transit manufacturing industry is crucial for safeguarding their well-being, avoiding accidents, and sustaining a highly productive and efficient workplace. The following are essential health and safety measures to be implemented in the industry.

Employee Training and Education
Personal Protective Equipment (PPE)
Safety Protocols for Machinery and Equipment
Fall Protection
Hazard Communication
Emergency Response Planning
Health and Wellness Programs
Environmental Controls
Machine Guarding
Risk Assessment and Management
Regular Audits and Inspections
Continual Improvement

## 4.METHODOLOGY

In our project, we aim to reduce the risk of fire incidents through the implementation of the fire load stupidity method. This method involves assessing the calorific values of various materials commonly present in our industry, such as paper, plastic materials, and wooden pallets. By determining the calorific value of each material and considering its weight, along with the occupied area, shall calculate the fire load stupidity. The fire load density is a crucial metric that helps us to understand the potential fire hazard associated with the materials in our facility. This information enables us to make informed recommendations for risk mitigation. For materials with high fire load density, such as paper, plastic, and wooden pallets, we may propose alternative materials with lower calorific values, such as steel or cardboard. This substitution can

significantly reduce the overall fire risk in our workspace. Additionally, we will recommend the implementation of additional fire safety measures. This may include the strategic placement of fire extinguishers or the installation of fire hydrants at key locations. These precautions are designed to enhance our ability to respond promptly and effectively in the event of a fire, minimizing the potential impact on human safety and safeguarding production materials and records. By systematically assessing and addressing the fire load density of materials in our facility, as well as implementing proactive measures, we aim to create a safer working environment. This comprehensive approach not only reduces the likelihood of fire incidents but also establishes a robust framework for protecting both personnel and critical assets within our industry.




## 4.1 MATERIAL IDENTIFICATION

In the realm of fire risk management, it is crucial to identify combustible materials present in the rail transit and manufacturing industries that could potentially ignite fires within occupancy areas. To effectively calculate and mitigate the fire load density within industry premises, understanding the quantity and type of these combustible materials is paramount. The materials under consideration include:

Wooden Furniture in admin block
Paper in the office areas
Plastic Materials in the shop floor, warehouses & office
Diesel in storage yard
Cooking Oil in the kitchen
LPG in the yard
Cloths

## 4.2 QUANTITY OF MATERIAL

In the fire load calculation, the quantity of combustible materials in various locations is detailed in the following table. The combustible materials considered include Wooden Furniture, Paper, Plastic Materials, Diesel, Cooking Oil, LPG, and Cloths. The respective quantities of these materials are recorded in the table alongside their designated locations within the structure. This comprehensive documentation facilitates an accurate assessment of the fire load for each material type in different areas, allowing for a thorough analysis of the overall fire risk and aiding in the implementation of effective fire safety measures.

| S.NO | LOCATION | ITEAM DESCRIPTION | QUANTITY IN KG |
|---|---|---|---|
| 1 | Administrative Office | Wooden Furniture Paper Plastic Material | 3250 |
| 2 | PED | Wooden Furniture Paper Plastic Material | 1090 |
| 3 | Canteen | Cooking Oil LPG | 260 |
| 4 | OHC | Wooden Furniture Paper clothes | 92 |
| 5 | LPG Cylinder Area | LPG | 1140 |
| 6 | Coupler FG Warehouse | Wooden Pallets Plastic Material | 2550 |

**FIG 1: QUANTITY OF MATERIAL**

### 4.3 AREA OF OCCUPANCY

The calculation of fire load necessitates the determination of the area of occupancy, which is obtained by multiplying the length and breadth to derive the total floor area. Various locations within the project, such as the administrative block, PED (Process Engineering Department), canteen, OHC (Occupational Health Canter), LPG Cylinders Storage area, and Coupler FG warehouse, are considered for the calculation of fire load.

| S.No | LOCATION | AREA Sq. Mt |
|---|---|---|
| 1 | Administrative Office | 833 |
| 2 | PED | 576 |
| 3 | Canteen | 667.8 |
| 4 | OHC | 64 |
| 5 | LPG Cylinder Area | 105.3 |
| 6 | Coupler FG Warehouse | 188.4 |

**FIG 2: AREA OF OCCUPANCY**

### 4.4 FORMULA AND FIRE LOAD CALCULATION

An important factor in establishing the basis for the assessment of the fire risk pertaining to any building is the concept of ‘fire load’ which indicates the quantity of heat liberated per unit area when a building and its contents are completely burnt. All occupancies/buildings, etc. can be graded according to their fire hazard and are to be provided for with suitable fire precautions on the basis of the fire load. Hence, grading of buildings according to both fire load and fire resistance can be made. The formula for calculating fire load is as stated.

$$\text{Fire load} = \frac{\text{(combustibles in kg) x calorific value in kcal/kg}}{\text{Floor area in square meters}}$$

The calculation of the fire load is the basis for the determining the classification of the occupancies for the fire grading of buildings.

### 4.5 FIRE GRADING OF THE STRUCTURES:

Structural element of buildings is graded according to the time factor which is nearly equal to but does not exceed the test period which the element fulfils its specified requirements.

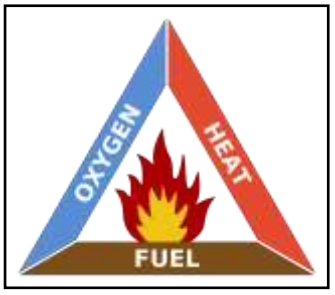
Accordingly, all structural elements have been graded under the following five categories depending upon their five resistances, viz.,

Grade 1…… 6 hours
Grade 2…… 4 hours
Grade 3…… 2 hours
Grade 4…… 1 hours
Grade 5…… 0.5 hours

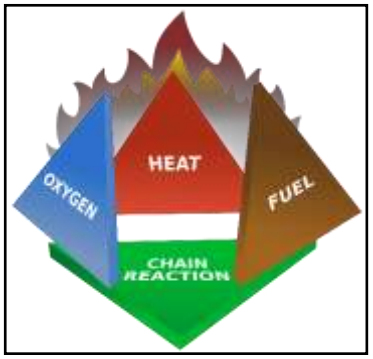
**4.6 STANDARD REFERENCES:**

This analysis compares fire safety requirements in various standards and regulations, focusing on key aspects to enhance understanding and promote informed decision- making. The comparison is divided into two sections: Compartmentation, which evaluates how each standard restricts fire spread through building design and construction; Fire Detection and Alarm Systems, which examine mandated systems, alarm activation criteria, and notification protocols; Firefighting Equipment, which examines requirements for portable extinguishers, fixed firefighting installations, and water supply systems; Means of Escape, which explores design and capacity standards for staircases, exits, and emergency lighting provisions; Electrical Safety, which reviews measures to prevent electrical fires, including wiring standards, overload protection, and grounding; and Employee Training and Fire Drills, which assesses the importance of occupant preparedness and evacuation procedures. The analysis also examines explicit limits vs. indirect control, classification systems, impact on fire protection requirements, and risk assessments. It emphasizes the importance of consulting qualified fire safety professionals for compliance with relevant standards and regulations based on specific building characteristics, occupancy, and fire risk. Fire safety is a crucial aspect of building design and operation, ensuring occupant safety and minimizing potential property damage.

Fire is one of the major causes in the industrial area and there is increasing rates of fire accidents which may kill the life of the people. The fire can cause due to three main components such as Oxygen, Fuel and Heat is also known Fire triangle. When oxygen supply is increased in the fire area the amount of fire burning rate increases so that heat can be generated in huge amount. To suppress the fire one of the components must be removed. The suitable fire extinguishers must be used to suppress the fire triangle so that fire can be easily put off.




This completes the classic fire triangle's fourth addition. The fuel and oxygen go through a complicated series of chemical reactions in it. After a fire is started, the heat it produces keeps these reactions going, producing more heat and extending the combustion process.




To suppress the fire on of the components such as oxygen, Fuel and Heat must be removed so that burning rate of fire will be reduced Fire alarm system is one of the essential needs and must be installed in the building where there are combustible materials present in it. In case of fire, it is very useful to migrate and can be detected easily. Fire hydrants and fire extinguishers must be installed where there is risk of fire. The suitable fire extinguishers must be kept so that in case of fire it can be easily suppressed. Fire hydrants must be installed outside to suppress the building of fire. Fire hydrants are external fire extinguishers and portable fire extinguishers are internal fire extinguishers.

| CLASSES OF FIRE | COMBUSTIBLE MATERILAS | EXAMPLES |
|---|---|---|
| Class A | Solids | Wood, Plastic and Rubber |
| Class B | Flammable Liquids | Thinner, Petrol, and Diesel |
| Class C | Flammable Gas and vapour fires | LPG & LNG |
| Class D | Combustible metals | Magnesium, potassium, titanium, and zirconium |
| Class E | Fires involving energized electrical conductors | Electricity |
| Class K | Kitchen | Cooking oil |

**FIG 3: CLASSES OF FIRE**

### 4.6.1 TYPES OF FIRE EXTINGUISHERS

Handling the CO2 extinguisher must be careful because the cold discharge may lead to cold burns in hands.

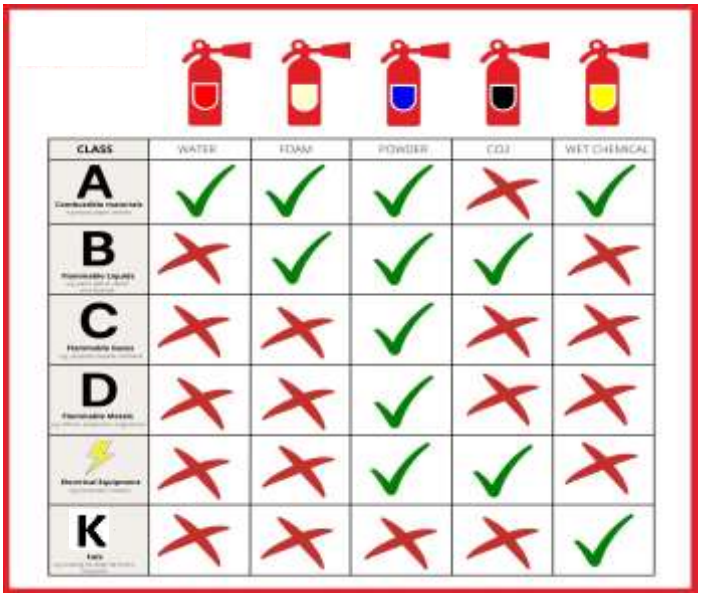



**FIG 4: TYPES OF FIRE EXTINGUISHERS**

## 5. RECOMMENDATION & DEPLOYMENT

When attempting to properly deploy fire extinguishers, must take a few crucial precautions to make sure they are suitable for the fire hazards in your outdoor space and easily accessible. The following are some essential suggestions and directives for choosing and using fire extinguishers:

### 5.1 FIRE LOAD OCCUPANCY IN EACH SECTION:

According to the above fire load calculations the occupancy of fire density shows in the table below and the graph.

| S.NO | SECTION NAME | FIRE LOAD OCCUPANCY |
|---|---|---|
| 1 | Administrative Building | **55.642** |
| 2 | Processes Engineering Department (PED) | **36.227** |
| 3 | Canteen | **17.37** |
| 4 | Occupational Health Centre | **25.422** |
| 5 | LPG Cylinder area | **595.441** |
| 6 | Coupler FG Warehouse | **279.67** |

**FIG 5: FIRE LOAD OCCUPANCY**

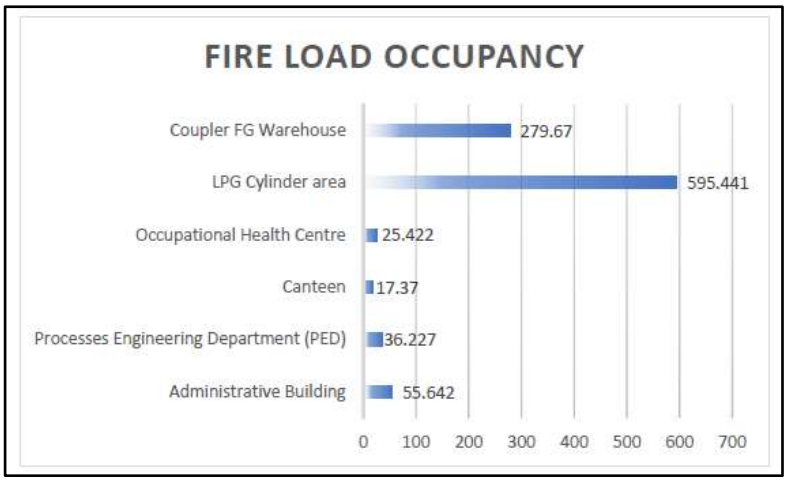



**FIG 6: BAR CHART: 1**

The bar chart shows that the fire load density available in the two section the LPG cylinder area and the Coupler FG warehouse. According to the bar chart, fire suppression is to be installed.

### 5.2 A S S E S S FIRE RISKS:

Identify the types of fires likely to occur in your setting (e.g., Class A, B, C, D, E, & K fires). Consider the materials present that could fuel a fire (wood, paper, flammable liquids, electrical equipment, etc.). The fire load calculation was derived above for the all the sections of the rail manufacturing industry.

### 5.3 S E L E C T THE RIGHT TYPE OF FIRE EXTINGUISHERS:

Choose extinguishers suitable for the identified fire risks. Common types include:

Water (Class A): For ordinary combustibles like wood and paper.

Foam (Class A and B): Effective on flammable liquids like gasoline.

Dry Chemical (Class A, B, C): Works on a variety of fires including flammable liquids and electrical fires.

Carbon Dioxide (Class B, C, Electrical): Suitable for electrical fires and flammable liquids.

Wet Chemical (Class K): Specifically, for kitchen fires involving cooking oils and fats.

### 5.4 PLACE EXTINGUISHERS STRATEGICALLY:

Install extinguishers in easily accessible locations near potential fire hazards.

Ensure they are visible and unobstructed.

Place them along escape routes, near exits, and in high-risk areas (e.g., kitchens, workshops, mechanical rooms).

The placement of the extinguishers would always be free from obstructions.

Fire extinguishers available here's signage or red with white zebra paint must be behind the fire extinguisher's wall.

### 5.5 CONSIDER EXTINGUISHER RATINGS:

Check the fire extinguisher's rating to ensure it matches the size of the potential fire. Ratings are typically expressed as a number and letter (e.g., 2A:10B:C).

### 5.6 P R O V I D E TRAINING:

Educate employees or residents on how to use fire extinguishers effectively. Conduct regular fire drills and training sessions.

### 5.7 MAINTENANCE AND INSPECTION:

Regularly inspect extinguishers to ensure they are fully charged and in working condition. Follow manufacturer's guidelines for maintenance and servicing.

### 5.8 F O L L O W REGULATIONS:

Adhere the Tamil Nadu Fire Service Act 1985, Tamil Nadu Fire Service Rules 1990, Tamil Nadu Factories Act 1948 and Tamil Nadu Factories Rules 1950. Adhere the relevant Indian standards related to the fire protection & Preventions. Adhere to local fire codes and regulations regarding the placement, type, and maintenance of fire extinguishers.

### 5.9 T Y P E S OF MOUNTING:

Use wall mounts or stands appropriate for the size and weight of the extinguisher. Mount extinguishers at an accessible height (750 mm from the bottom of the fire extinguishers).

### 5.10 ADDITIONAL CONSIDERATIONS:

Consider additional safety equipment based on your needs, such as fire blankets or automatic fire suppression systems. Regularly review and update your fire safety plan based on changes in your environment or operations.

## 6. CONCLUSION

For the fire load calculations project, we propose to mitigate fire hazards by employing calorific value methods. This approach aims to prevent fires by assessing the calorific values of various materials, determining the area of material occupancy, and adhering to established standards for fire calorific values in each material. Our recommendations focus on replacing high-calorific-value combustible materials with those possessing lower calorific values, such as cardboard and steel. Additionally, we measure the area of occupancy to determine the appropriate placement of fire-fighting equipment, including suitable fire extinguishers, fire hydrants, and sprinklers. This strategy ensures the safety of plant workers and overall plant security. This project has the potential to significantly reduce the occurrence of fire hazards in our industry.

## 7.REFERENCES

1) J. LIU, W. K. CHOW (2014), "Determination of fire load and heat release rate for high-rise residential buildings", 2014ISSST, International Symposium on Safety Science and Technology, Procedia Engineering 84 (2014), pp. 491 – 497.
2) N. Arunraj, C. Senthil Kumar, K. Vijaya Maruthi (2015), "Estimation of Fire Load and Its Risk Assessment in Warehouse", SSRG International Journal of Industrial Engineering (SSRG – IJIE) – Volume 2 Issue 2, pp. 2349 – 9362.
3) Ugur Dundar, Serdar Selamet (2022), "Fire load and fire growth characteristics in modern high-rise buildings", Fire Safety Journal 135 (2023) 103710.
4) Manish Nigam, Awadhesh Kumar Singh, Abhishek Dixit (2016), "Fire Load Calculation on Hospital Buildings in India", 2016 IJEDR, Volume 4, Issue 2, ISSN: 2321-9939.
5) Kiran Pawar, Gauri Rane (2021), "Fire Load Density and Fire Adequacy – An Important Tool for Firefighting", ISSN: 2455-0620 Volume - 7, Issue – 5, pp. 128- 132.
6) Christophe Thauvoye, Bin Zhao, Jochen Klein, Mario Fontana (2007), "Fire Load Survey and Statistical Analysis", Wolfgang-Pauli-Straasse 15, 8093 Zurich, pp. 992-1002.
7) Karthick Suresh, G. Lokesh (2021), "Fire Risk Assessment and Fire Load Calculation in Manufacturing Industry", ISSN (PRINT): 2393-8374, (Online): 2394-0697, Volume-8, Issue-4.
8) Karthick M, Ravi M (2020), "Study of Fire Risk Adequacy", IJRAR, International Journal of Research and Analytical Reviews, Volume 7, Issue 1, pp. 694-706.