Estimation of Fire Load and Its Risk Assessment in Warehouse

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Abstract

Fire is the major hazard which may occur in the automobile industry. There is an increase in accidents and the losses due to fires are

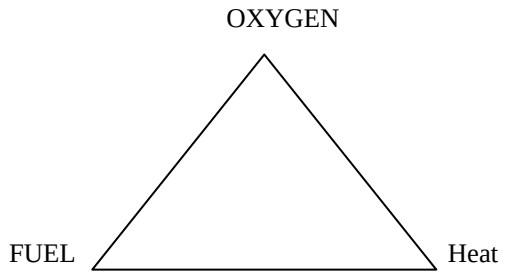
- *Loss of human life*
- *Loss to the life of structure of material*
- *Loss to property*

The fire loads and fire densities were analyzed at Warehouse of Ashok Leyland to find the requirements of firefighting equipments in the industry. There are various methodologies to reduce the fire load in the industry which must be done to reduce the fire risk. The increasing use of engineering solutions needs to identify, characterize and quantify design fires for buildings. The characteristics of fire such as ignition, heat release, and flame temperature of design fires depend on the weight and arrangement of combustible materials. This paper includes the total fire load calculations in various buildings and the locations so that fire loads can be calculated which creates hazards to the environment so that combustible materials can removed and engineered solutions can be given to reduce the fire risk.

Index Terms—*Firefighting, Fireload*

I. INTRODUCTION

Fire is one of the major cause 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.



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 is combustible materials present in it. In case of fire, it is very useful to migrate and can be detected easily.

Fire hydrants and fire extinguisher must be installed where there is risk of fire. The suitable fire extinguishers must be kept so that incase 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

Table 1. Classes of Fires

CLASSES OF FIRE	COMBUSTIBLE MATERILAS	EXAMPLES
Class A	solid	wood, plastic, rubber
Class B	liquid	kerosene, petrol, liquid gas
Class C	gas and electrical appliances	electrical appliances and combustible gases
Class D	combustible metals	magnesium, potassium, titanium, and zirconium

A. Classes Of Fire

CLASS A

Class A fires consist of ordinary combustibles materials which are of solid type such as wood(all types of wood), paper, fabric, plastic and most kind of trash

CLASS B

Class B fires consists of fire which are of liquid type namely of liquid gas, petrol and kerosene which can cause fire easily when exposed to fire.

CLASS C

Class C fires consists of gaseous state and also electrical fires. Electrical circuit and appliances can be used to suppress the fire using class C Fire extinguishers

CLASS D

Class D fires are namely metals which are magnesium, potassium, titanium, and zirconium etc. These metals are combustible metals which comes under class D fires.

B. Types of Fire Extinguishers

1) Water Fire Extinguisher

Water fire extinguishers are common fire extinguisher which are used to suppress the fire such as solid materials likely wood. The main use of Water fire extinguishers is the use of water as an suppression agent. This type of fire extinguisher is only used for class A type fire .

2) Foam Fire Extinguisher

Foam fire extinguishers are water fire extinguishers. This type of fire extinguishers which can be used both for class A and B type i.e., it can suppress combustible material and also flammable liquids and gases.

3) Dry Powder Extinguisher

Dry Powder fire extinguishers are used for all types of fire extinguisher as they can be used for Class A, B and C type fires. Dry powder chemical extinguishers can be used to suppress the electrical hold applicances like electrical circuit.

4) CO2 Extinguisher

CO_2 fire extinguishers are mainly used for extinguishing class B and C fires. The extinguishing agent takes away heat element in the fire triangle by very cold discharge. Handling the CO2 extinguisher must be careful because the cold discharge may lead to cold burns in hands.

Table 2 Classification of fire extinguishers

Fire Extinguishers	Different Types of Fire			
Types	Solid	Liquids	Gases and electrical circuits	Metal fires
Water	/	X	X	/
Foam	/	/	X	X
Dry Powder	/	/	/	/
CO_2	X	/	X	X

II. METHODOLOGY

Estimation of combustible material of a building can be determined by three methods They are

- direct measurement of mass, with conversion based on the net heat of combustion
- direct measurement of volume (with conversion based on a combination of density and net heat of combustion)
- energy release measurement by calorimetry of an item sufficiently

Fire load density is defined as the amount of heat liberated from a combustible material per square meter in floor area. Fire load is to determine the severity and building up of fire. Fire load is an useful in determining the growth and severity of fires. The mass of the material is calculated in kg. The calculated mass is multiplied by its calorific value in MJ/kg to get fire load. The calculated value is then divided by area of the floor to give fire load density. Hence the fire load equation is shown in equation (1).

$$qc = \frac{\sum Hv\ mv}{Af} \quad (1)$$

Where,

q_c = Fire Load density in MJ/m^2

m_v = Total mass of v^{th} combustible material in kg

H_v = Calorific value of v^{th} combustible material in MJ/kg [3]

A_f = Area of floor in m^2

Table 2 Calorific Values of Some Common Combustible Material Used in Package Section

Materials	**Calorific value in MJ/kg**
Polythene cover	17.5
Poly Propylene	42.66
Wood	18.6
Carton box	16.9
Paper (average)	16.3
Centre cushion foam	40
Rubber	27.5

Fire load densities were calculated in Bin location of warehouse Located in Ashok Leyland,Unit-1,Hosur,Tamil nadu,India. The section contains Bin location of AM,AN,AR and centre cushion

The mass of combustible products is calculated by digital weight meter. If the mass is unknown, volume of the material is calculated in m^3 and the calculated volume is multiplied by density of the material in kg/m^3. So the formula for calculating mass is given as,

Mass = Volume * Density

III. FIRE LOAD CALCULATIONS

Table 3 Fire Load Calculation for Bin Location AM

Bin location AM : Area [30*1*4.5 = 135 m^3]				
Combustible Materials	Total in Numbers	Weight in kg	Calorific value in MJ/kg	Fire load in MJ
Carton box	23139	11569.5	16.9	195524.55
Wooden pallet	87	1392	18.6	25891.2
Polythene cover	23139	46.278	17.5	809.865

Fire Load density = (195524.55+25891.2+809.865) / 135

= 1646.115 MJ/m^3

Table 4 Fire Load Calculation for Bin Location AN

Bin location AN : Area [30*1*4.5 = 135 m^3]				
Combustible Materials	Total in Numbers	Weight in kg	Calorific value in MJ/kg	Fire load in MJ
BlueCarton box	67049	33524.5	16.9	566564.05
Brown carton box	1000	1000	16.9	16900
Wooden pallet	80	1280	18.6	23808
Polythene cover	67049	134.098	17.5	2346.715

Fire Load density = (566564.05+16900+23808+2346.715) / 135 = 4515.695 MJ/m^3

Table 5 Fire Load Calculation for Bin Location AR

Bin location AR : Area [30*1*4.5 = 135 m^3]				
Combustible Materials	Total in Numbers	Weight in kg	Calorific value in MJ/kg	Fire load in MJ
Blue Carton box	78353	39176.5	16.9	19522.25
Brown carton box	1200	1200	16.9	20280
Wooden pallet	80	1280	18.6	23808
Polythene cover	78353	156.706	17.5	2742.355

Fire Load density = (19522.25+20280+23808+2742.355) / 135

=491.500MJ/ m^3

Table 6 Fire Load Calculation For Centre Cushion Foam

Bin location centre cushion : Area [4*2.5*2 = 20 m^3]				
Combustible Materials	Total in Numbers	Weight in kg	Calorific value in MJ/kg	Fire load in MJ
Brown carton box	60	60	16.9	1014
Wooden pallet	16	208	18.6	3836.8
Polythene cover	94	0.188	17.5	3.29
Centre cushion foam	774	928.8	40.9	37987.92

Fire Load density = (37987.92+1014+3868.8+3.29) / 20 = 2143.7005MJ/m^3

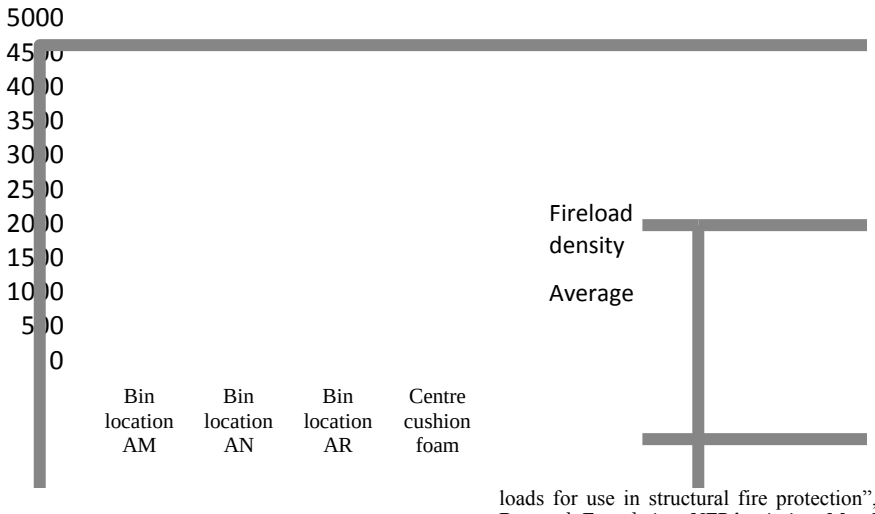
IV. RESULT AND DISCUSSIONS

The fire load density for Warehouse in Ashok Leyland which has Bin location AM, AM, AR and Centre cushion is calculated and summary is shown in table 7.

Table 7 Fire Load Density for Combustible Material

Sl.no.	Area of location	Fire load in MJ	Floor area in m^3	Fire load density in MJ/m^3
1	Bin location AM	222225.615	135	1646.115
2	Bin location AN	609618.765	135	4515.695
3	Bin location AR	66352.605	135	491.500
4	Centre cushion foam	42874.01	20	2143.7005

From the above table it is known that the bin location AN has the highest fire load of 4515.695MJ/m^3 and the lowest is bin location has 491.500 MJ/m^3. The maximum fire load is due to more number of carton boxes and wooden pallets stacked one on another. The lowest fire load is AR where the carton boxes are splitted and stacked onit.



The huge difference in graph is due to highly combustible material in the bin location of AN. The carton boxes are splitted so that the amount of fire load is reduced and the potential barrier like iron between the location is kept so that the fire cannot spread on each other and the fire fighting equipments such as A,B, C type can be used to quench the fire easily. The average fire load in bin location is 2199.252MJ/m3.According to National building code(NBC) states that Sprinkler systems and Fire alarm must be kept where there is huge amount of fire load for fire suppression in case of fire

V. CONCLUSION

Fire load density is analyzed in a warehouse in manufacturing industry is done and the study gives following conclusion:

The maximum fire load density is found in bin location AN is 4515.695MJ/ m^3. Minimum is in bin location AR 491.500 MJ/ m^3 and the average value of fire load density in package section is given as 2199.52 MJ/m^3.

The usage of wooden pallets, polythene cover and other carton box material can be reduced to reduce fire load density.

The substantial barrier must be kept between the bin location like irons so that fire cannot spread over to top of the rack and fire can be quenched easily.

Fire possibilities in Warehouse are only solid fire so A, B and C type fire extinguishers can be used around the bin location

As the fire load density is very high in Warehouse the reduction of carton boxes is impossible. According to National building code(NBC) part4, fire fighting equipments like alarm systems and sprinkler systems must be be installed in.

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