FIRE PROTECTION OF COMBUSTIBLE BUILDING MATERIALS

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ABSTRACT

Various natural and synthetic polymeric materials such as cellulose and its derivatives, plastics, rubbers and foams etc. are generally used in buildings. These materials are combustible and hence pose great fire hazards.

A few fire retardant compositions based on ammonium phosphates, borate salts, amides, polyhydric alcohols, antimony oxide and a halogenated copolymer alongwith a binder have been developed for imparting flame retardancy to cellulosic materials. Fire performance and emission of smoke have been evaluated employing different BS and ASTM standards. The results were found well within the limits. On exposure, the coated specimens showed neither any surface spread of flame nor any after glow combustion. On the other hand the paint films swelled to form spongy, cellular insulating foams which acted as effective barriers against the conduction of heat.

INTRODUCTION

Fire hazard is a very serious problem faced by almost every country. A large number of fire incidents occur every year causing considerable loss of life and property. Combustible materials easily catch fire if appropriate fire protection measures are not employed. Various natural and synthetic polymeric materials viz. cellulose and its derivatives, plastics, rubbers and foam etc. are finding extensive use in buildings in a variety of forms for diverse applications such as doors, windows, decorative wall and ceiling linings, thermal and acoustical insulators, textile furnishings, floor coverings, partitioning of rooms, electrical fixtures and cables etc. All these materials constitute a major fire load inside a building due to their combustible nature. They play a very important role in spread of fire from the place of origin to other remote areas of the building. Smoke and toxic gases evolved by burning the above materials cause hindrance in protecting life by physical incapacitance and reduced visibility. Burning characteristics of a few materials which are widely used in buildings are given in Table 1 (Ref.1). The use of that combustible materials cannot, however, be avoided, inspite of their undesirable burning characteristics. If we have the correct evaluation of fire performance characteristics fire protection treatment of these materials may be appropriately devised and a proper selection of the building materials can be made.

SPREAD OF FIRE IN BUILDINGS

It is important to find out the cause of origin of fire if an effective fire protection treatment is envisaged. Break out of a fire essentially needs : (a) fuel in this case combustible building materials (b) heat temperature above the ignition point of the materials and (c) oxygen. They can be represented by a triangle of fire 2. The absence of any one of these will not allow a fire to occur.

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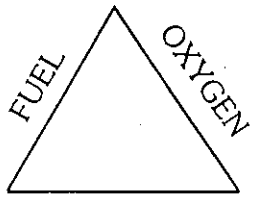

TRIANGLE OF FIRE

Fire can be initiated by a small source such as an electric spark, a glowing cigarette, and a match flame etc. The ignition source raises the temperature of a small portion of the material to a critical value when the combustion process starts which can become self sustaining. Fire can then spread via combustibles and grow. Every fire involves three stages i.e. growth, full development and decay. The last state occurs when all the available fuel is exhausted or the fire is otherwise extinguished (Fig. 1)3. The growth stage is clearly one in which fire can be controlled most effectively.

MINIMISATION OF FIRE

There are generally two methods employed for controlling the spread namely fire extinguishment and fire prevention.

Conventional means of fire fighting are water, carbon dioxide, dry chemicals, fire fighting foam wetting agents and sprinklers etc. which are applied after fire takes place. To extinguish a fire, at least one of the three essentials (fuel, oxygen and heat) must be removed. These essentials can be removed by starvation i.e. removal of fuel supply or by smothering i.e. removal of oxygen supply or by cooling the system i.e. removal of heat. Fire is usually detected only after it attains serious proportions and only then the fire brigade is called. Thus, by the time, the fire fighters start taking action for fire control, considerable time is lost. The problem is still worse with high rise buildings because of the difficulties in approaching the upper portions of the buildings. Therefore, fire prevention must always take precedence over fire extinguishment.

Considerable efforts are spent in fire protection of commercial buildings and their contents. There has been comparatively little attention paid to reduce fire spread through materials as they are the combustible contents and contribute largely to the fire load in a building. Restricting surface spread of fire can help in evacuation of occupants of the building and give time for the fire fighting personnel to reach the site before the fire goes out of control. Suitably treated materials will not allow the fire to spread. Delaying the fire spread by a few minutes can be of great advantage in saving property and life to a considerable extent. This article deals only with fire retardant treatment as a measure for prevention of fire spread and growth.

Fire Retardant Treatments

Several different methods for rendering a material fire retardant such as (i) impregnation (ii) spray (iii) surface treatment (iv) incorporation of chemicals during manufacturing stage have been used.

A flame retardant treatment should essentially possess the following characteristics :

* It should be non toxic and may not produce toxic decomposition products.
* It should not reduce the strength and finishes of the materials.
* It should be easy to apply, cheap and easily available.

The chemicals largely employed for fire retardance are either chemical compounds or mixture of compounds of phosphorus, nitrogen, sulphur, boron, halogen and antimony 4-6. THPC (Tetrakis hydroxy methy phosphonium chloride), APO (Aziridiny Phosphine Oxide), phosphory lamide and various combination of THPC APO have been investigated by various workers to achieve fire retardancy 4-9. In terms of fire resistance, these treatments seem to be somewhat more efficient. However, a single combination has not been commercialised due to the high cost of chemicals, their toxicity and problems in application.

It is therefore, worthwhile to develop a few

cheap and effective fire retardant treatment for combustible materials. These treatment include :

Impregnation of Chemicals

Fire retardant solutions based on ammonium phosphates, sulphates, chlorides, borates etc. were used to render cellulosic materials fire retardant. The solutions were applied by immersion and spray methods. These treatments have temporary effect on fire retardancy of materials, however, experiments have been conducted at Fire Research Laboratory to improve the durability of these treatments. Cellulosic materials such as curtain, carpets, upholstery, bed sheet and sarees etc. were treated and their fire performance was studied using standard test methods (Table 2).

Surface treatment

Two types of coating i.e. non intumescent and intumescent have been often used. First type is based on the synergistic effect of antimony oxide and halogenated compounds. Volatile reaction products like antimony trichloride are formed in burning process act as flame supperssants. Such coatings are prone to damage by prolonged heating as the surface film cracks and permits heat penetration to the materials.

Intumescent coatings have certain basic ingredients in addition to those of pigments, resins, plasticizers etc. which give them their individual characteristics as paint. These basic ingredients are a source of carbon, blowing agent and a catalyst. On application of heat such paint film puffs up and produce a tough insulating foam which protects the material efficiently. The main advantage of these coating over the non intumescent type is their stability at high temperature and prolonged heating.

A few intumescent coatings have been developed and their fire performance studied after application on various substrates. Fire performance of coatings is given in Table.3.

CONCLUSION

Each year fires in buildings are causing heavy property losses more so because of recent trends in high rise apartment buildings and increased use of combustible materials for various purposes. Inspite of burning characteristics of such materials, their use can not be avoided. Fire prevention always must take precedence over fire extinguishing. From a fire safety point of view caution must be excercised while using such materials in buildings. Only those materials which have acceptable fire performance should be used. Since such materials are not easily available, therefore, the fire performance of combustible building materials must be improved by suitable fire retardant treatments. The suitably treated materials will no more be dangerous from the fire point of view.

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TABLE-1 BURNING BEHAVIOUR CHARACTERISTICS OF MATERIALS.

Materials	Thickness	Non combus-tibility Test	Ignita-bility Test	Fire Propagation Index		Flame spread class	Smoke Density, D_m Non Flaming
				I_1	I		
Kailwood	12mm	C	P	16.14	41.50	4	328.7
Plywood	6mm	C	P	7.47	25.52	3	-
Particle Board	12mm	C	P	14.21	36.52	3	410.0
Fibre Board	12mm	C	P	33.10	56.00	4	308.1
PVC Profile	21mm	C	P	cannot be classified			383.5
PVC flooring	2mm	C	P	7.72	20.03	4	186.0

LEGAND

C	Combustable
P	Not easily ignitable
i_1	Sub index (Initial burning only)
I	Fire performance index
Class 1	Surfaces of very low flame spread
Class 2	Surfaces of low flame spread
Class 3	Surfaces of medium flame spread
Class 4	Surface of rapid flame spread
D_m	Maximum specific density of smoke generated.

The lower of numerical value of the indices i_1, I and D_m the better a material is.

TABLE-2 FIRE PERFORMANCE OF COTTON FABRICS

Material	After flame (sec)	After glow (sec)	Char length cm	Char area Cm^2
Standard Test Method: BS 3119				
Curtain Cloth	0	0	5.6	5.34
Bed Sheet	0	0	6.1	5.79
Upholstery	0	0	6.0	5.70
(Control)	Burn completely with flames in 18-20 secs			
Standard Test Method : BS 4790				
Carpet	0	0	-*	2.0
Control	9	48	-*	6.5

* Not applicable.

TABLE-3 FIRE PERFORMANCE OF INTUMESCENT COATING

Coated Material	ASTM D-1360 Wt Loss (gm)	Char Vol.(CC)	PERFORMANCE AS PER BS:476 Pt. 6 i1	I	BS:476 Pt-7	ASTM E-662, SOD (Dm) Non flaming
Fibre board(12mm)	3.78	7.66	2.43	13.78	Class-1	38.35
Particle Board(12mm)	2.92	6.05	2.12	12.97	Class-1	41.05
Plywood (6 mm)	3.18	7.18	3.05	14.52	Class-1	38.45
Kailwood (12mm)	3.26	6.37	2.96	16.19	Class-1	39.92

Fire Performance of control specimens is given in Table-1.

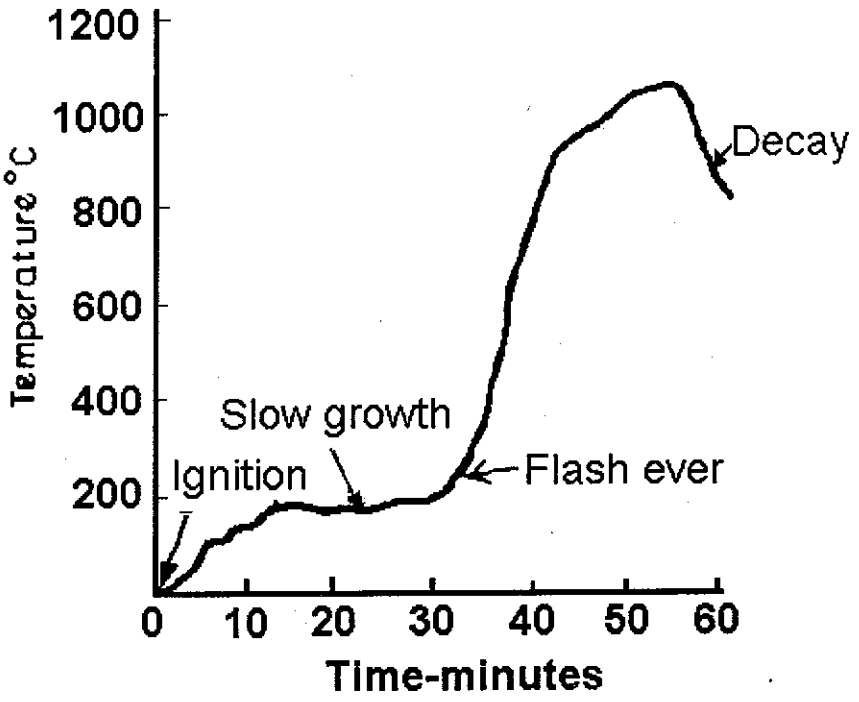

FIGURE 1. POSSIBLE COURSE OF A FULLY DEVELOPED BUILDING FIRE