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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
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THE EFFECT OF FIRE RETARDANT MATERIALS ON THE SMOULDERING OF FIBRE INSULATION BOARD

by

K. N. Palmer

Summary

The efficacies of three water-soluble fire retardant treatments and one fire retardant paint in preventing the smouldering of fibreboard have been studied. The treatments were applied to the surface of the board specimens and measurements were then made of the rates of smouldering in still air and under applied airflows. The amounts of water-soluble retardants to be added to the board to prevent sustained smouldering are sufficiently large to make application of the treatments difficult and also to alter the physical properties of the board. In practice, therefore, it may be simpler and more profitable to take other steps to prevent the initiation of smouldering in fibreboard, or to use other, less flammable, types of material.

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Introductory

A short series of experiments has been carried out following a request for information on the possibility of preventing sustained smouldering in fibre insulation board, used as the lining for an air duct, by the addition of materials normally considered as flame retardants. The inquiry arose because fire retardant paints could not be used in the duct. The treatments tested were : an aqueous solution of borax and boric acid, an aqueous solution of borax only, and an aqueous solution of ammonium dihydrogen phosphate. The effects of a fire retardant paint and of distilled water were also investigated, for comparison.

Materials

A sample of fibre insulation board, 1.3 cm in thickness, was sawn into strips 15 x 7.5 cm and known volumes of one of the following compositions were applied to the surface of the board:

Borax - boric acid solution:	56 gm commercial borax 44 gm " boric acid 20 ml surface active agent made up to 1 l. solution with distilled water.
Borax solution:	56 gm commercial borax 20 ml surface active agent made up to 1 l. solution with distilled water.
Ammonium dihydrogen phosphate solution:	100 gm commercial ammonium dihydrogen phosphate. 20 ml surface active agent made up to 1 l. solution with distilled water.
Surface active agent solution:	2 per cent agent in distilled water.
Fire retardant paint:	A suspension of intumescent paint (powder) in water, in the ratio 1.82 : 1 by weight.

Method

In the main series of experiments known volumes of solution were applied from pipettes to the board strips, usually to both faces of the board; the amounts of fire retardants thus added are given in Table 1. The presence of the surface active agent dissolved in the solutions aided the wetting and penetration of the board surface; from direct visual observation it was estimated that the board was wetted to a depth of about 0.3 cm, the depth of penetration being comparatively independent of the volume of solution added. The average amount of fire retardant added to this wetted zone of the board may be easily calculated; for example, by considering the application to the board of a quantity of solution sufficient to deposit 0.0150 gm of fire retardant per cm^2 of board surface. Then, if the density of the board is 0.25 gm/ml, the zone of the board wetted by the solution will, on drying, contain 20 per cent by weight of fire retardant. After impregnation the boards were dried in an air oven at 40°C, overnight. In other experiments

one coating of fire retardant paint was applied to the board by brushing; the volume added is given in Table 1. After treatment each strip was conditioned until equilibrium in a constant humidity chamber maintained at 60 per cent R.H. and 70°F.

After the conditioning smouldering was initiated at one end of each strip by a gas flame, the strip was then held by a clamp at one end, with the board faces horizontal, either in still air or in a wind tunnel, and the rate of propagation of smouldering (cm/hr) measured. When treatment was applied to only one board face this face was held uppermost.

Estimations of the ease of initiation of smouldering were made with selected board samples using, for sources, glowing cigarette ends in one of three positions: resting on a board face, in contact with two faces meeting at a 90° corner, and in contact with a frayed edge of the board. These experiments were carried out under an air flow of 100 cm/sec (2.2 m.p.h.).

Results

The smouldering rates of the boards after treatment are given below. Three rates of air flow were used, in addition to still air, and the values given in the Table are correct to within ± 8 cm/sec.

TABLE 1

The smouldering rates of treated fibreboard strips

Treatment	Volume added to unit area of board ml/cm²	Weight of solid on unit area of board. gm/cm²	No. of board faces treated	Smouldering rates (cm/hr) at air velocities * of			
				0 cm/sec	100 cm/sec	225 cm/sec	350 cm/sec
Surface active agent solution. (control)	0.075	-	2	6.8	12.0	21.2	22.8
Borax-boric acid solution.	0.194	0.0194	2	n.s	n.s	n.s	n.s
	0.150	0.0150	2	n.s	n.s	n.s	n.s
	0.075	0.0075	2	n.s	8.5	n.s	n.s
	0.038	0.0038	2	5.7	12.0	9.5	10.4
	0.225	0.0225	1	n.s	n.s	8.3	n.s
Borax solution.	0.225	0.0126	2	7.2	21.3	32.5	32.4
Ammonium dihydrogen phosphate solution.	0.150	0.0150	2	n.s	n.s	n.s	n.s
	0.075	0.0075	2	n.s	n.s	7.0	7.4
	0.038	0.0038	2	4.5	7.4	5.8	n.s
Fire retardant paint.	-	0.029	1	n.s	-	16.0	19.6
	-	0.029	2	n.s	n.s	n.s	n.s

n.s. - smouldering not sustained.
* - (44.7 cm/sec = 1 m.p.h.)

Treatment of the board specimens with the borax-boric acid solution usually caused appreciable roughening and hardening of the board surface, comparable to that with the fire retardant paint. A similar effect was also obtained with the ammonium phosphate solution applied at 0.150 ml/cm^2.

The addition of fire retardant materials noticeably increased the amount of carbonaceous residue formed during the smouldering. With the exception of the board treated with paint, however, both faces of the board specimens were charred if smouldering was sustained; the board treated with fire retardant paint (one face only) behaved differently as the painted surface was only browned although the paint was blistered, the unpainted face carbonised in the normal manner.

The results of experiments with glowing cigarette ends showed that smouldering could be initiated easily, under an airflow, at frayed edges of the board or where two board faces met at a corner. A cigarette end lying exposed on a board face did not initiate smouldering after several attempts irrespective of whether or no the board was treated with fire retardants. It was concluded that if a board would sustain smouldering in an air draught then it could be ignited by a favourably placed glowing cigarette end.

Discussion

The experiments with the water soluble treatments have shown that the borax-boric acid mixture and the ammonium dihydrogen phosphate treatment are more effective in preventing smouldering than borax alone. The efficiencies of the borax-boric acid and of the ammonium dihydrogen phosphate treatments may be seen from Table 1 to be approximately the same; with each treatment fairly heavy applications are required, on both faces of the fibreboard. If only one face of the board is available for treatment, and the solution is applied by spraying the board surface, then the amount to be added to prevent smouldering may be too great for practical use.

When both faces of the board are available for treatment at least 0.0150 gm/cm^2 of the borax-boric acid mixture is required on each face for smouldering to be prevented, under conditions tested; this entails the absorption of 1 gal. of the fire retardant solution in about 32 sq.ft of fibreboard, using the strength of solution specified above. It is probable that if this amount were applied in one operation an appreciable volume of the liquid would not penetrate the board, but would run off; unfortunately the borax-boric acid solution used was almost saturated and it would not be possible to reduce appreciably the volume of liquid to be applied. The impregnation could however be made in several stages, allowing the board to dry out between each application. In practice, therefore, it may be more convenient to apply ammonium dihydrogen phosphate since a solution of double the strength of that used in the above experiments can be prepared; the volume of liquid to be added would then be halved.

The application of one coat of the fire retardant paint, made up according to the manufacturer's specification, was sufficient to prevent smouldering under the experimental conditions if the paint was applied to both faces of the board. After drying, the weight of paint thus applied to the board was about twice the amount of the borax-boric acid mixture or the ammonium dihydrogen phosphate required to prevent smouldering under the same experimental conditions. The paint would however, probably be easier to apply.

If either of the water soluble treatments is used it is clearly important to ensure that the application is spread evenly over the board face. Particular care should therefore be taken if the solution is applied by spray to make certain that all corners and edges of the board are thoroughly impregnated, since it is at these places that ignition by a small source, such as a glowing cigarette end, can most readily occur. The probability of ignition by such sources in a duct

lined with fibreboard could be reduced by taking other precautions, such as by covering the board edges and the corners between faces by an incombustible material, preferably metal. In any event it is of great importance that no dust, rag, or other combustible material should be allowed to accumulate in contact with the fibreboard, even if the latter is treated, since such tinder may be easily ignited and a resulting fire would be supported and intensified by the fibreboard.

A further precaution against the development of fire may be taken by attempting to exclude all sources of ignition from coming into contact with the fibreboard. Thus all openings into a duct lined with fibreboard should be protected by fitting wire gauze of sufficiently fine mesh to prevent the passage of cigarette ends, or igniting sources of similar size. Finer meshes would of course be necesary to hinder the entry of smaller sources, such as sparks, or flames (from blow lamps). In many cases precautions such as these may be of more practical value in preventing smouldering fires in fibreboard than attempting to treat the board with fire retardant materials. During the designing of constructions such as air ducts consideration should also be given to the possibility of using materials presenting a lesser fire hazard than fibreboard.

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