F.R. Note 382
Research Programme
Objective F.5/4(C).

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

THE FLAMMABILITY OF FABRICS IN COMPRESSED AIR

by

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Summary

Experiments to determine the effect of increased air pressure on the flammability of fabrics have shown that increased air pressure decreased the protection afforded by a flame retardent treatment, but it appears that the generally recommended 10 per cent addition of boric acid/borax mixture affords a useful protection. The effect of compression is therefore similar to that of enrichment with oxygen, although less in degree.

F.1025/21/13.
January, 1959.

Fire Research Station,
Boreham Wood,
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Corrections to F.R. Note No. 382

THE FLAMMABILITY OF FABRICS IN COMPRESSED AIR

Page 2, Table 1, Column 3. Burning time of 15 cm x 1 cm strips at atmospheric pressure should be 14·4 seconds and NOT 15·3 seconds.

Figures 2, 3 and 4 to be replaced.

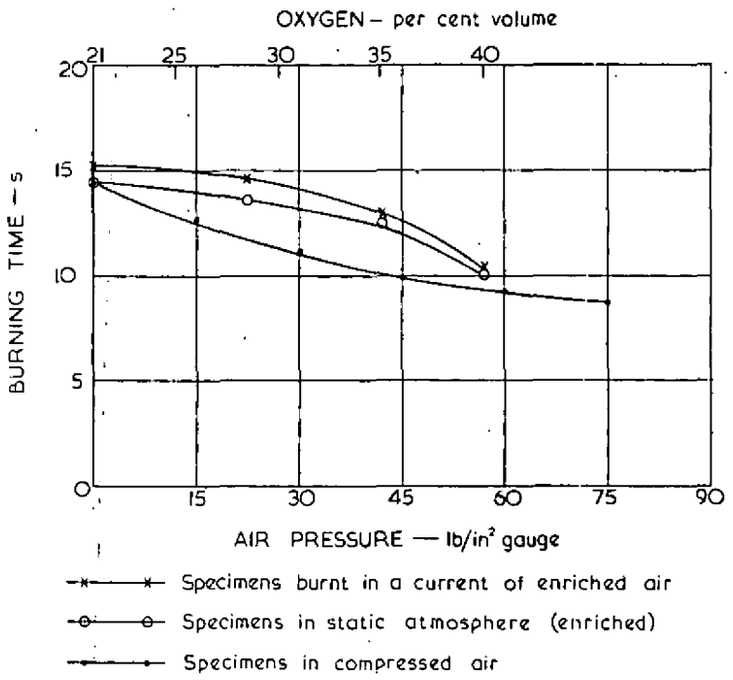
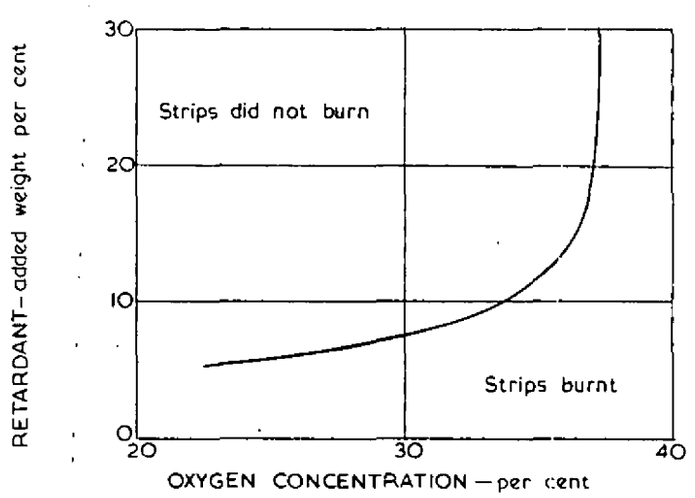


FIG.2. EFFECT OF AIR PRESSURE & OXYGEN CONTENT ON BURNING TIME



183 cm strips of white drill impregnated with a mixture of 70 per cent borax and 30 per cent boric acid

FIG.3. OXYGEN & RETARDANT CONCENTRATION AT LIMITS OF FLAMMABILITY

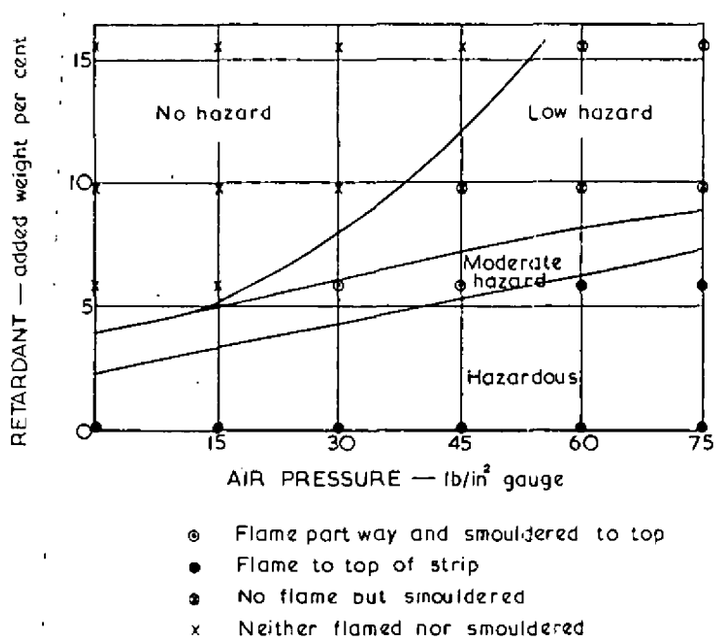


FIG.4. THE EFFECT OF AIR PRESSURE ON THE COMBUSTION OF WHITE DRILL IMPREGNATED WITH A MIXTURE OF 70% BORAX & 30% BORIC ACID. STRIPS 15cm x 1cm

THE FLAMMABILITY OF FABRICS IN COMPRESSED AIR

Introduction

Experiments[1] showed that the hazard from burning is greatly increased when fabrics are used in atmospheres enriched with oxygen.

Work is often necessary in compressed air and in such an atmosphere the amount of oxygen available per unit of area of fabric will be increased. Although the amount of diluent nitrogen would also be increased it seemed probable that the effect of increased air pressure would be similar to that of oxygen enrichment, and experiments have been made to measure the hazard and the amount of protection afforded by flameproofing treatment.

Experimental

The experiments were made with a white unbleached cotton drill weighing 9.6 oz/yd^2 as used in earlier experiments[1]. In those experiments specimens 183 cm x 5 cm were burned in a chamber 220 cm high x 30 cm square with a stream of enriched air flowing at 40 changes per hour. It was not possible to pressurize this vessel and therefore the present series of experiments was made with specimens 15 cm x 1 cm burned in a perspex cylinder, (60 cm high x 14 cm diameter) Fig.1. in which pressures up to 75 lb/in^2 could be used.

Measurements were made with the fabric suspended in free air, in the vessel at atmospheric pressure and at 15, 30, 45, 60 and 75 lb/in^2, in atmospheres of air enriched with oxygen, and also in a current of enriched air. Experiments were also made in compressed air with the fabric impregnated with a mixture of 70 per cent borax and 30 per cent boric acid.

As in the previous experiments the specimens were conditioned for 24 hours in air at 67°F and 67 per cent relative humidity before being tested.

The effect of changing the condition was measured by the time for complete combustion of the strip, measured visually because it was not possible to introduce an automatic recorder into the apparatus.

The fabric strip was ignited by the combustion of a strip of celluloid 12 mm x 3 mm x 0.1 mm attached to the bottom, and the celluloid was ignited by a short length of 30 S.W.G. nichrome wire heated electrically.

Results

Comparison of the effects of compression and enrichment of the air

The results of tests made in the pressure vessel at different pressures, in an atmosphere of enriched air, and in a current of enriched air, are given in Table 1, and have been plotted in Fig.2. The results from previous experiments[1] with 183 cm strips have been included in the table.

TABLE 2

The effect of air pressure on the time for combustion of fabric impregnated with a flame retardant

Treatment of strip	Added wt. per cent.	Burning time (sec)									
		Atmospheric pressure		15 lb/in^2		30 lb/in^2		45 lb/in^2		60 lb/in^2		75 lb/in^2	
		Flame	Smouldering	Flame	Smouldering	Flame	Smouldering	Flame	Smouldering	Flame	Smouldering	Flame	Smouldering
None		15.3	-	12.8	-	10.9	-	9.9	-	9.3	-	8.7	-
Boric Acid 30 per cent Boric Acid 70 per cent	5.75	Did not burn		Did not burn		None	401	*2 to 3	99	*2 to 3	98	14	37
						*10	136	*7	189	13	41	11	31
	9.7	Did not burn		Did not burn		Did not burn		None	387	None	316	None	280
	15.7	Did not burn		Did not burn		Did not burn		Did not burn		None	383	None	260

*Specimen did not flame to the top.

In the previous experiments with 183 cm strips the effect of different retardants was compared by the limiting oxygen and retardant concentrations for combustion. The curve for the 70 per cent borax 30 per cent boric oxide is reproduced in Fig.3. Similar criteria were adopted in this work and the results from Table 2 have been plotted in Fig.4. according to whether or not the specimen burnt or whether combustion ocurred with flaming or with smouldering.

The results, can be separated into four groups. There is a hazardous group which flamed to the top, a group of no hazard which neither flamed nor smouldered, a group of low hazard in which combustion was completely by smouldering and a group of moderate hazard which flamed and smouldered. With these intermediate groups there would be time to removed burning clothing or to extinguish a fire, but there would be a risk of delayed fires from such causes as smouldering initiated by hot metal from welding or flame cutting. The amount of after glow or smouldering would be different with different retardants.

By comparison of the results with long strips in oxygen (Fig.3) and short strips in compressed air (Fig.4) it appears that a 10 per cent addition of the boric acid/borax mixture (a weight commonly recommended) would give protection in up to approximately 34 per cent of oxygen or up to 38 lb/in^2 compressed air. In the first instance the oxygen concentration is 1.6 times atmospheric and in the second is 2.5 times. Increasing the oxygen content by enrichment is thus shown to produce a greater effect than increasing by air compression.

Conclusions

The results have shown that increasing the oxygen content of the atmosphere by compression produces similar effects to increasing the oxygen by enrichment. There is a difference in degreee, caused probably, by the differences between the oxygen/nitrogen ratios, enrichment producing a greater effect than compression.

Although tunnelling equipment may be operated at pressures as high as 4 atmospheres, usual pressures are between 15 and 30 lb/in^2 guage(2), and the accepted pressure in which work can be carried out without special precautions is 18 lb/in^2. (3). It is thus possible to provide clothing of low flammability for use in compressed air.

Acknowledgements

Mr. G.H.J. Elkin assisted with the design of the apparatus and Mrs. P.M. Hinkley and Mr. M. Danzig assisted with the measurements.

References

1) E. Coleman and G.H.J. Elkin. The Burning of Fabrics in Oxygen Enriched Atmospheres, Joint Fire Research Organization F.R. Note No.360/1958. June 1958.

2) Encyclopedia Britannica 1947 Edn. Vol.22. p.570.

3) The work in compressed air, special regulations 1958. Factories Act Statutory Instrument 1958/61.

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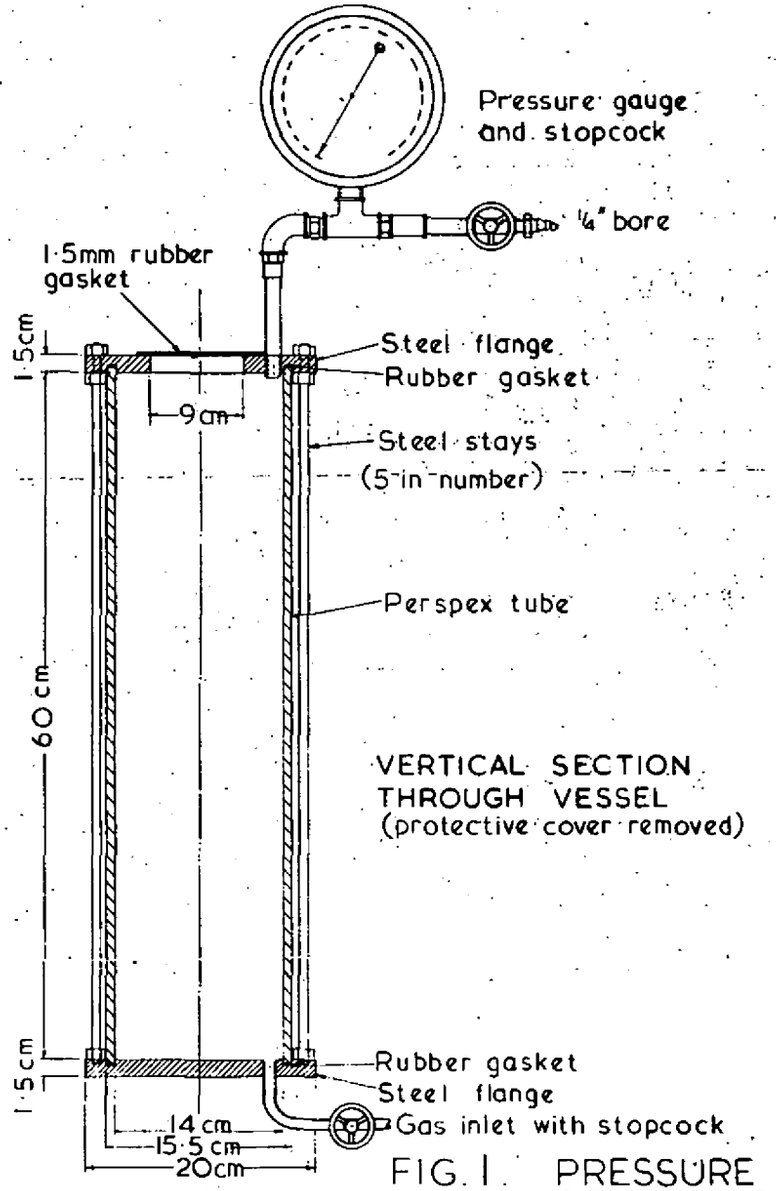
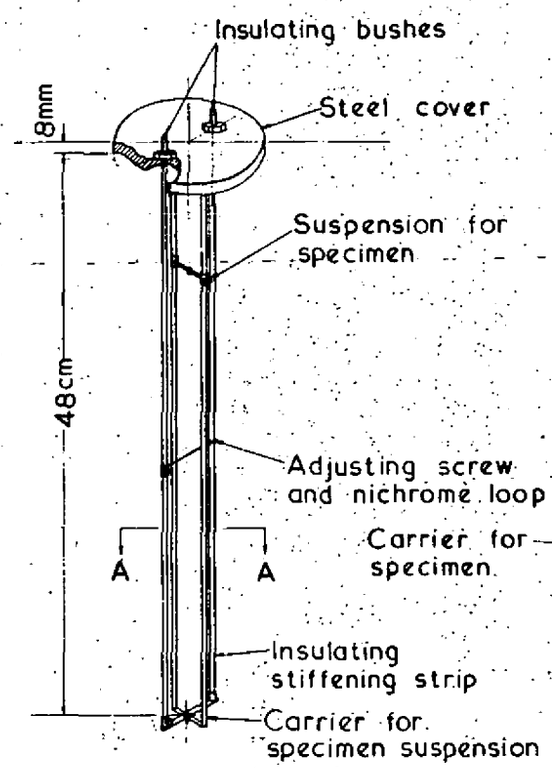
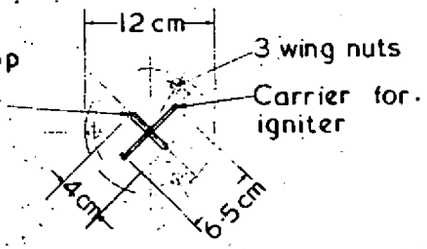


VERTICAL SECTION THROUGH VESSEL (protective cover removed)

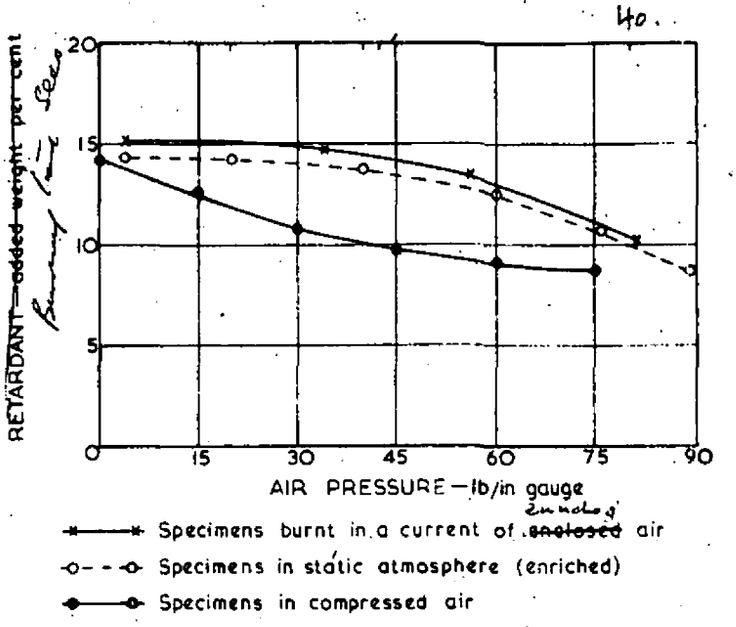


SUSPENSION AND IGNITION CARRIER



PLAN SECTION A-A OF SUSPENSION AND IGNITION CARRIER

FIG. 1 PRESSURE VESSEL FOR FLAMMABILITY OF FABRICS EXPERIMENTS



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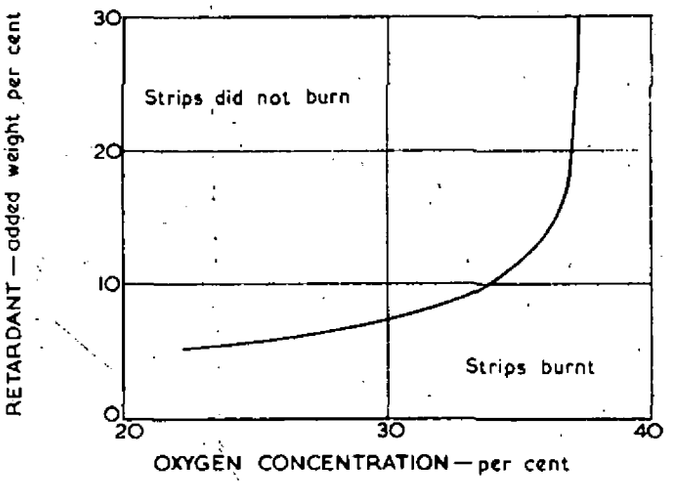

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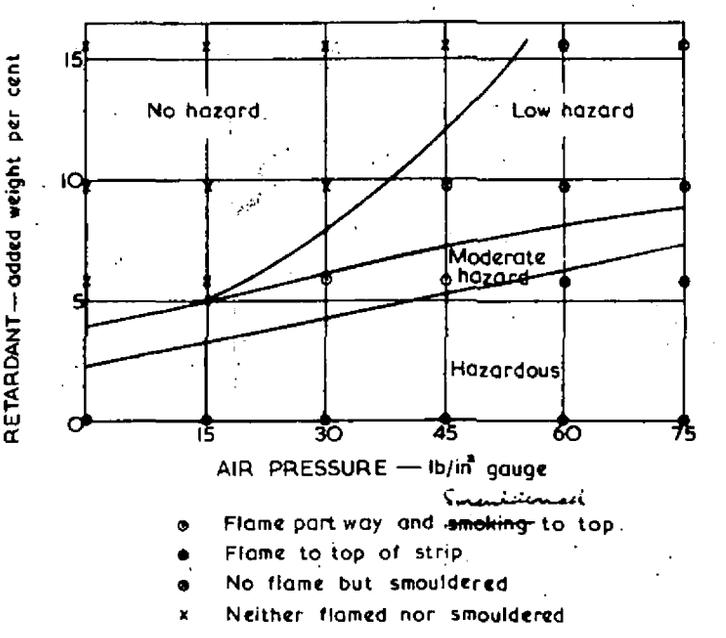

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