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

THE RELATIVE SENSITIVITY TO IGNITION OF TOWN GAS/AIR MIXTURES CONTAINING 18, 12 AND 6.5 PER CENT GAS

by

E. H. Coleman

Summary

The sensitivity of town gas/air mixtures containing 18, 12 or 6.5 per cent gas to ignition by aluminium paint sparks has been compared. using six paints examined in earlier work with 18 per cent gas. The results indicate that, under the conditions of test, a mixture containing 18 per cent gas was ignited more easily than mixtures containing 12 or 6.5 per cent. There is thus no reason to modify the conclusions drawn from the earlier work.

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Introduction

An investigation of the hazards from sparks from magnesium-base alloys has been made by the Safety in Mines Research Establishment [1]. Under the conditions of those experiments it was found that a 6.4 per cent mixture of methane in air was ignited more easily than richer mixtures. The initiation of the explosion was by sparks from the impact or friction of aluminium or magnesium on rusty steel or iron. The explanation suggested for the sensitivity of this weak mixture was that the combustion of the light metal consumed some of the oxygen around the point of impact and thus increased the local concentration of methane to a more flammable point. The mixture containing 6.4 per cent methane is thus not necessarily the most sensitive to ignition by other sources such as flames or electric sparks.

The work at the Joint Fire Research Organization [2], [3] on the spark hazard from aluminium paint was made with an 18 per cent mixture of town gas in air which was, at that time, considered to be the most easily ignited. In view of the results of the work at the Safety in Mines Research Establishment the earlier work has been reviewed, and fresh experiments made to ascertain whether the conclusions required modification.

Experimental

In this series of tests the paints were considered merely as igniting sources since it was the gas mixtures and not the paints which were being compared. Therefore from the results of the earlier work a selection was made of six paints which covered a variety of compositions and a range of incendivity of sparks produced from them. Fresh samples of the paints, described in Table 1, were obtained from the manufacturers.

The test procedure was the same used previously. A single coat of the paint was applied by brushing on to a well rusted mild steel plate $\frac{3}{8}$ in. x 3 in. x 8 in., and after drying for 48 hours at room temperature it was examined by striking in a dark room with a clean mild steel bar $\frac{3}{4}$ in. diameter and 12 in. long. Those specimens which gave visible sparks were then examined further by striking in an 18 in. cubical box containing a predetermined mixture of town gas and air. Preliminary experiments with a flint gas lighter showed that a 6.5 per cent mixture was the weakest which could be ignited in the box. Each painted specimen was examined in 18 per cent, 12 per cent and 6.5 per cent gas mixtures. The number of strokes that had been given when an explosion occurred was noted. If no explosion occurred with fifty strokes the sparks were considered to be non-incendive. The blows were glancing blows struck at random, and no attempt was made to vary the angle of impact or the force systematically. After being examined, the specimens were heated for 48 hours at 150°C, and after cooling were retested, first in the dark room and then in the explosion box. They were then heated to 200°C for 48 hours. The procedure was repeated and the heating temperature raised by 50°C at each repetition up to 400°C.

The results of the tests are given in Table 1.

TABLE 1

IGNITABILITY OF TOWN GAS MIXTURES

PAINT	Previous work (18 per cent gas)			Present Work					
	Results	Ref. No. F.C.(1) Note 33/1950 (1)	Ref. No. J. App Chem.(2) (2)	Preheating temperature °C	10 strokes in dark room		50 strokes in explosion box*		
					No. giving sparks	Brightness	Concentration of gas (per cent by vol)		
							18	12	6.5
Medium oil, varnish base.	Explosion at twenty-two strokes after heating to 250°C in gas but no explosion in gas or CS_2 after heating to 200°C.	8	2	Room	3	Medium	x	x	x
				150	3	feeble	x	x	x
				200	8	"	x	x	x
				250	10	medium	3	6	x
				300	10	bright	12	19	x
				350	10	med.bright	12	6	x
				400	10	" "	24	x	x
Long oil paint.	Explosion at twenty-four strokes after heating to 250°C. Explosion in CS_2 but not in gas after heating to 200°C.	9	37	Room	0	-	x	x	x
				150	0	-	x	x	x
				200	8	bright	x	x	x
				250	10	"	3	2	27
				300	10	medium	37	6	x
				350	10	med.bright	15	3	x
				400	10	very "	5	29	x
Alkyd base for 150°C.	Explosion at four strokes after heating to 300°C. Explosion in CS_2 but not in gas after heating to 200°C.	11	5	Room	0	-	x	x	x
				150	4	feeble	x	x	x
				200	10	very bright	x	x	x
				250	10	bright to brilliant.	3	3	29
				300		-ditto-	x	x	x
				350	10	bright	50	x	38
				400	10	med-bright	25	x	x

TABLE 1

(continued)

PAINT	Previous work (18 per cent gas)			Present Work					
	Results	Ref. No. F.C.(1) J. App Chem.(2) Note 33/1950 (1)	(2)	Preheating temperature °C	10 strokes in dark room		50 strokes in explosion box*		
					No. giving sparks	Brightness	Concentration of gas (per cent by vol)		
							18	12	6.5
Silicone for 600°C	No explosion but bright sparks after heating to 250°C.	16	10	Room	5	bright	x	x	x
				150	10	"	x	x	x
				200	10	"	x	x	x
				250	7	medium	x	x	x
				300	10	"	x	x	x
				350	10	"	x	x	x
				400	10	feeble to medium	x	x	x
Bituminous paint.	Explosion at twenty-three strokes after heating to 200°C.	18	12	Room	3	feeble	x	x	x
				150	0	-	x	x	x
				200	4	feeble	x	x	x
				250	10	"	x	x	x
				300	9	"	x	x	x
				350	10	med. to bright	x	x	x
				400	10	feeble to medium.	x	x	x
Synthetic resin for 600°F.	Explosion at fifty strokes after heating to 200°C.	17	11	Room	0	-	x	x	x
				150	4	medium	x	x	x
				200	10	bright	x	x	x
				250	5	feeble	x	x	x
				300	8	medium	x	x	x
				350	10	feeble to med.	x	x	x
				400	10	"	x	x	x

* Figures indicate that an explosion occurred at that number of strokes x indicates no explosion at fifty strokes.

Discussion of results

Since the blows were struck at random it is doubtful whether the number given before an explosion occurred can be considered to be a complete index of the sensitivity to ignition of the gas mixture, for an explosion could be caused equally probably by the first or the fiftieth blow, therefore, notice was taken only of whether or not an explosion occurred and the number of blows has not been taken into account, although the figures have been included in Table 1.

With each of the six paints there were twenty-one tests in each gas concentration. In the 126 tests there were twenty-two explosions, eleven in 18 per cent gas, eight in 12 per cent, and only three in 6.5 per cent.

No explosion was initiated by any specimen in either 12 or 6.5 per cent gas where there had not been an explosion in the 18 per cent mixture.

Incendive sparks were obtained only from the medium oil length paint (No. 8), the long oil paint (No. 9) and the alkyd base paint (No. 11).

Sparks from paint No. 11, preheated to 350°C caused explosions in 6.5 per cent and 18 per cent mixtures but not in 12 per cent. With this paint four of the six explosions produced occurred only after a large number of blows had been struck, and with the paint heated to 350°C the numbers were 35 and 50. Although the number of blows has not been regarded as an index of incendivity, it is reasonable to assume that there is less chance of an incendive spark from this paint than from one which consistently produced explosions from a smaller number of blows. For this reason sparks from paint No. 11 would be considered to be not very incendive, and thus the non production of explosion in the 12 per cent mixture is not considered significant in the evaluation of the different gas mixtures.

The results indicate that, in these experiments the 18 per cent gas mixture was the most sensitive of those examined.

This conclusion is apparently different from that obtained from the experiment at the Safety in Mines Research Establishment but there are several differences in the conditions which will have affected the results and which should be noted.

At the Safety in Mines Research Establishment the sparks were produced by a striker of solid metal weighted to 56 lb. which fell through distances varied between $1\frac{1}{2}$ and $7\frac{1}{2}$ ft. to strike a rusted steel girder. The energy dissipated was considerably more than at the Joint Fire Research Organization with a steel striker weighing $1\frac{1}{2}$ lb., manipulated by hand and striking a film of aluminium paint. The larger striker and greater expenditure of energy would be expected to produce larger flashes, consuming more oxygen. The effect of variations of gas concentration would thus be shown more with the bigger flashes. Additional to the differences between the effects of the energy expended, and the types of surface in contact, differences of gas composition also produce effects. Town gas contains high concentrations of hydrogen and carbon monoxide. The lower flammable limits of these are not far removed from that of methane, but the upper limits are very much higher. This increases the flammable range of town gas and the most sensitive mixture is not necessarily the same as with methane.

The brilliance of the sparks produced from paints No. 16, 17, 18 was reduced after the specimens had been heated beyond a particular temperature. This effect was noticed with some paints in the earlier work.

Visual observation of the sparks was not a reliable guide to the incendivity.

Conclusions

The results show that under the conditions of these experiments the conclusions from the results obtained in the earlier work with 18 per cent town gas do not need modifying.

Acknowledgement

The experimental work was carried out by Mr. P. S. Tonkin.

References

1. The ignition hazard from sparks from magnesium base alloys. S.N.A. Margerson, H. Robinson and H. A. Wilkins. S.M.R.E. Res. Rpt. No. 75.

2. E. H. Coleman, Z. W. Rogowski: F.C. Notes No. 28/1950 and No. 33/1950.

3. F. E. T. Kingman, E. H. Coleman, Z. W. Rogowski. J. App. Chem.(1952). 2 449.

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